this Issue:

ELECTRONICS AND GUIDANCE

TECHNOLOGY DEPT.

missiles and rockets

INCLUDING MISSILE ELECTRONICS

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MAGAZINE OF WORLD ASTRONAUTICS

AN AMERICAN AVIATION PUBLICATION

FEBRUARY, 1958

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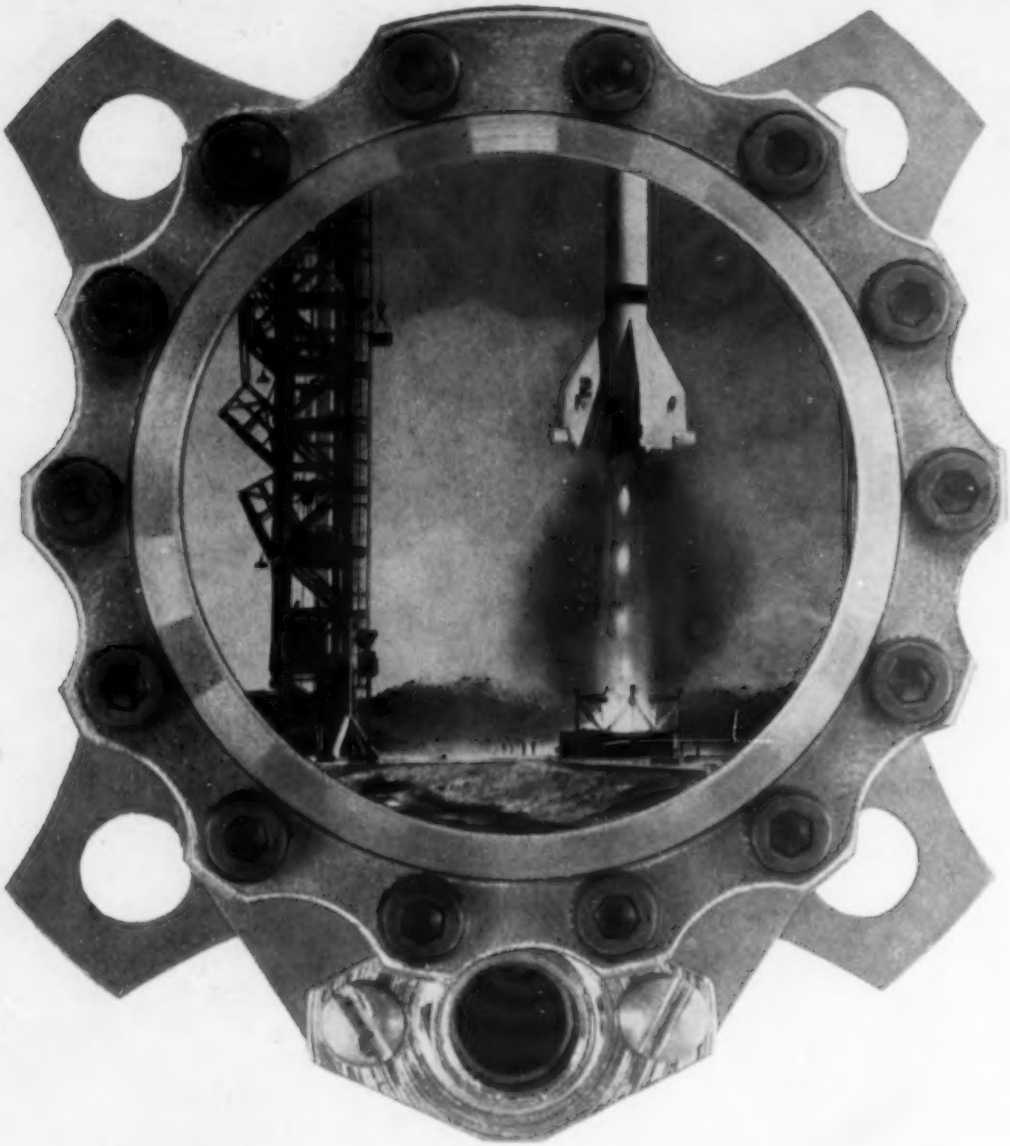

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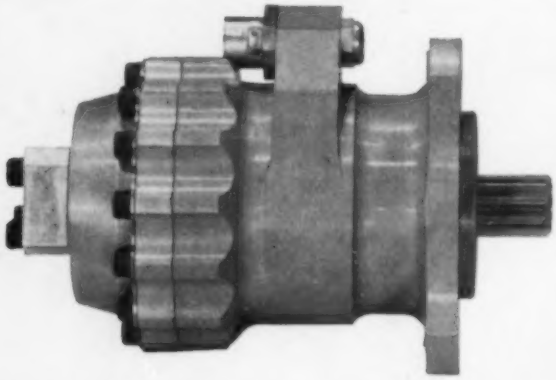

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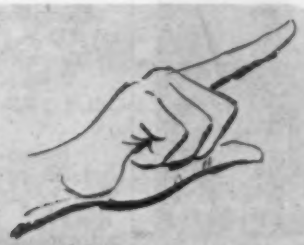

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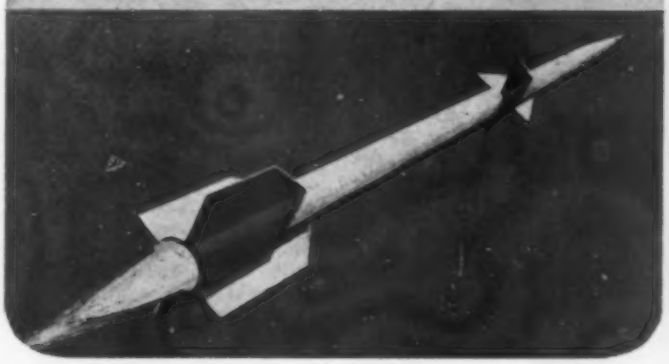

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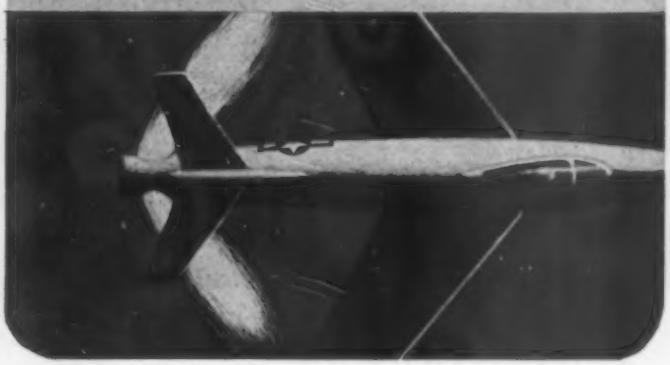

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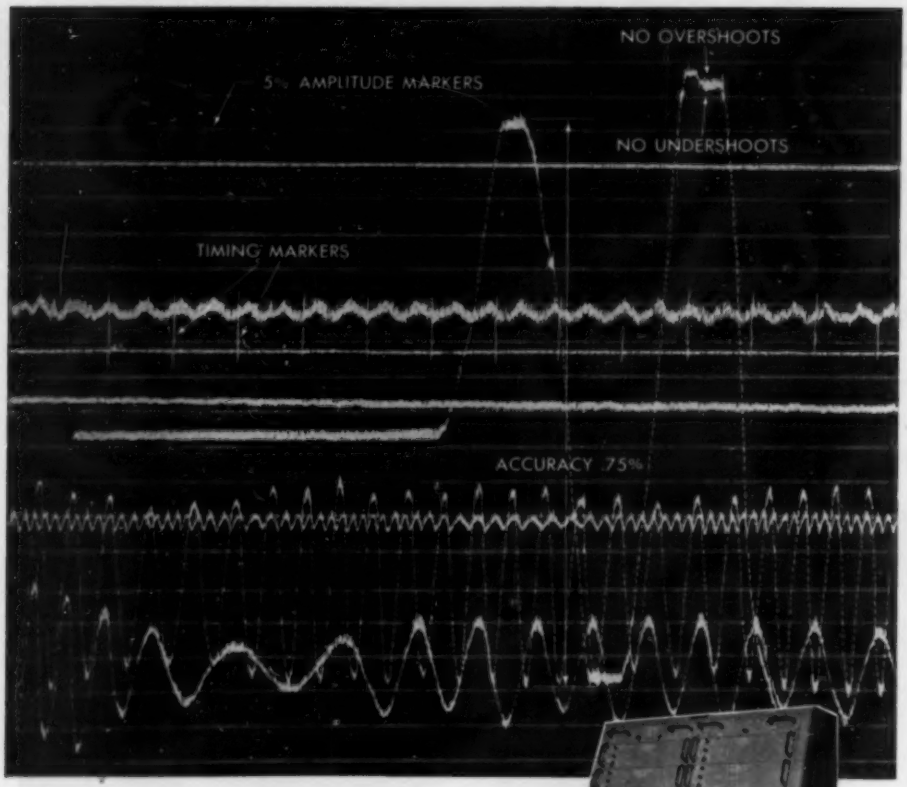

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cover picture:

Vanguard *test satellite: Sad symbol of American complacency! In the limelight and beset with troubles, TV-4 had still not been fired as m/r went to press—one week after starting countdown. Russia, with two* Sputniks *aloft, was waiting patiently for America to get its first artificial earth satellite aloft before launching a bigger more complex* Sputnik *III and shading out America's second-hand satellite glory. How different the story might have been if* Jupiter-*C had been okayed in 1956 will never be known. (See* Jupiter-*C story, p. 112.)*

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e·con′o·my: *when round-trip missiles save taxpayers $102,950,000*

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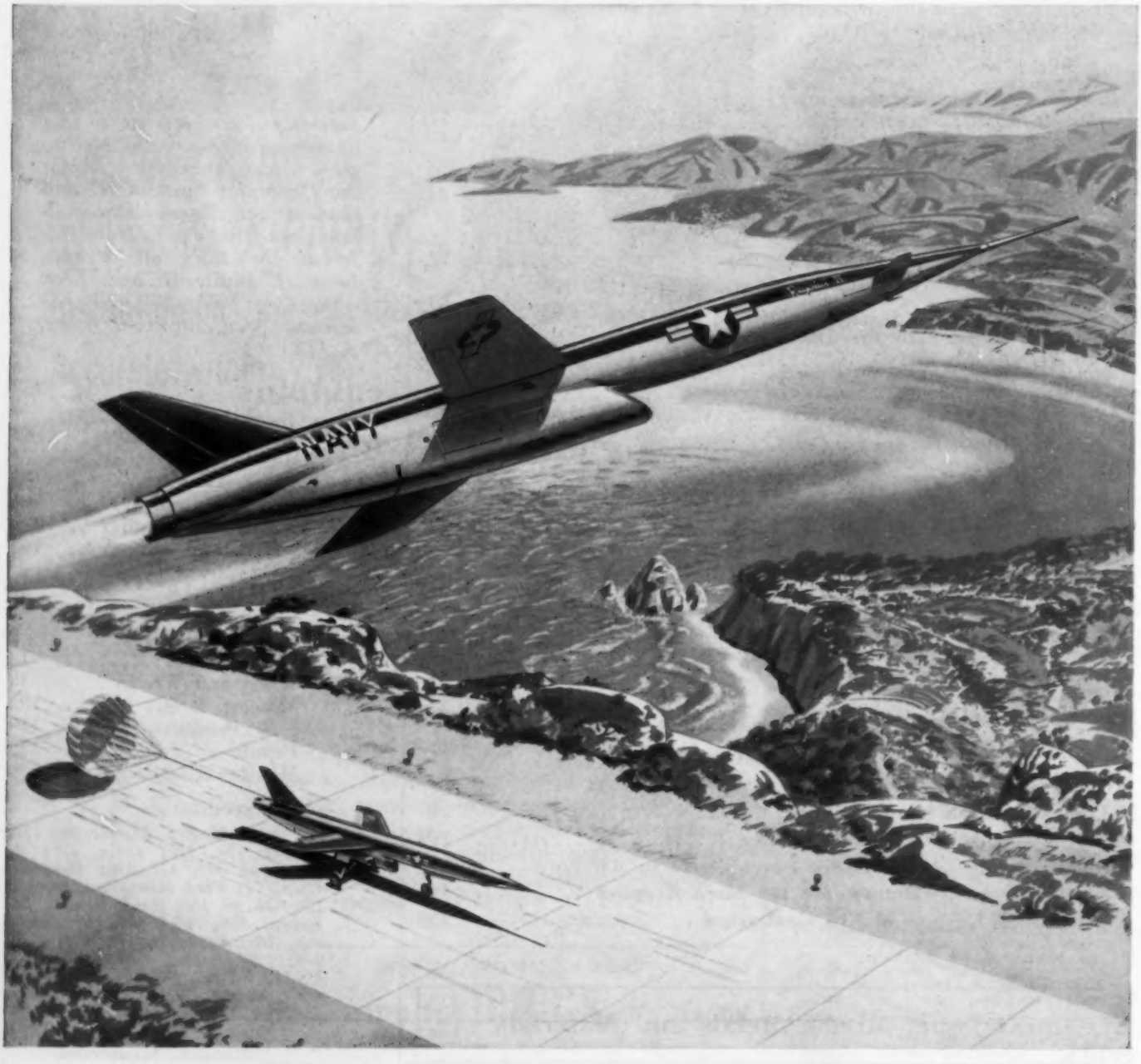

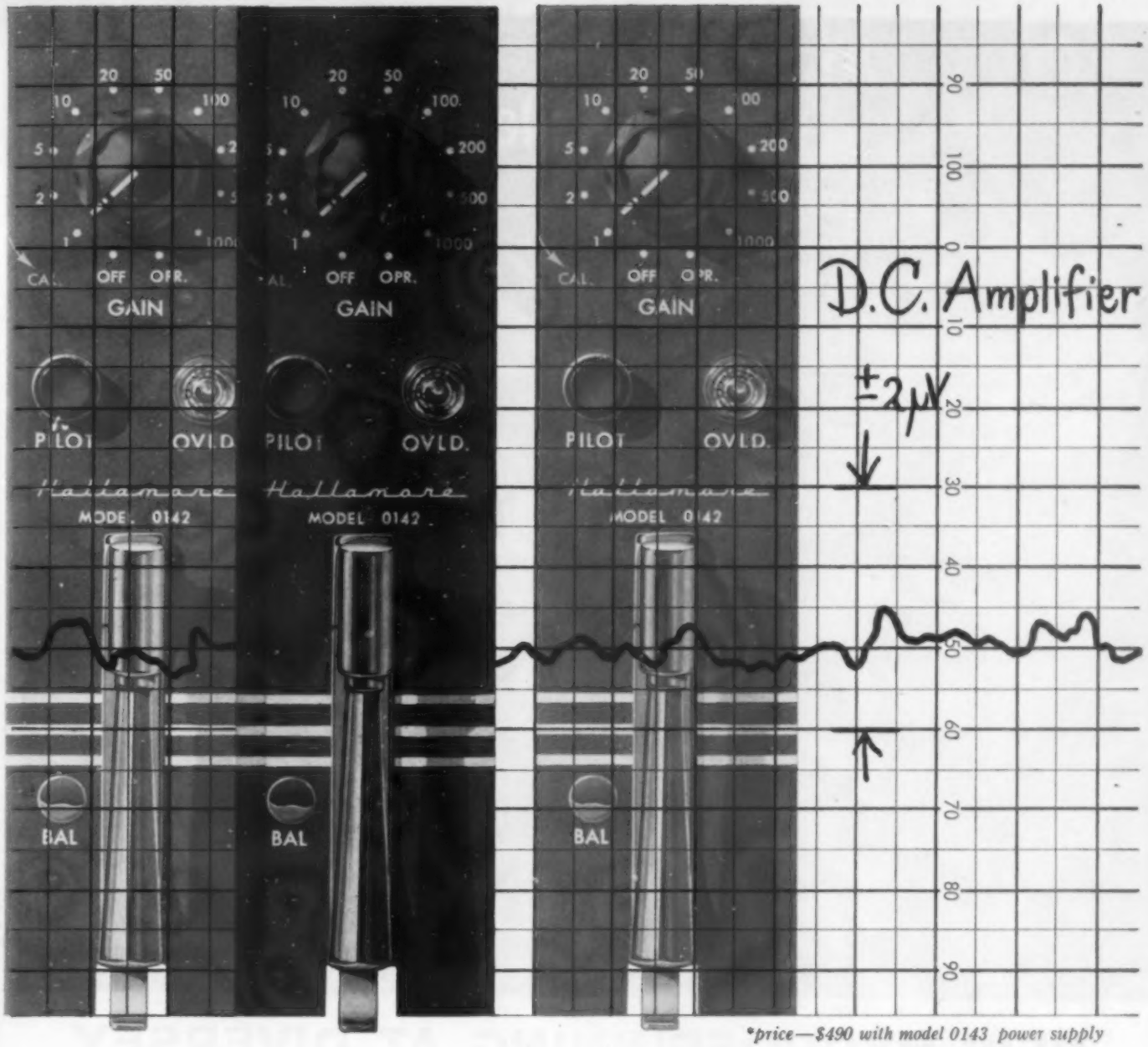

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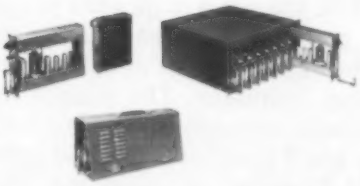

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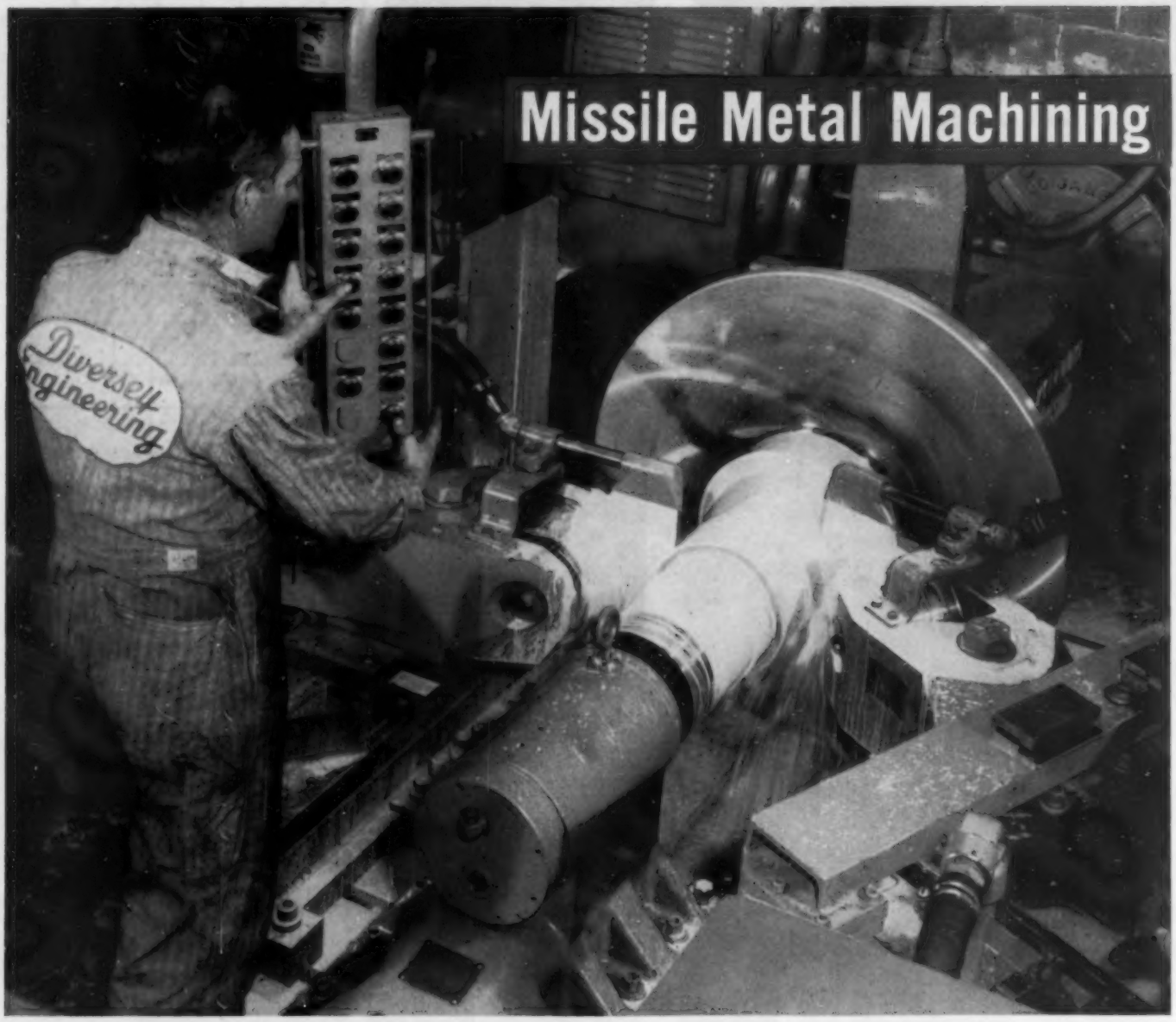

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Let's Use What We've Got!

The United States will continue to trail Russia in space technology and missile science in 1958. But this year will mark the beginning of a new era for Americans, because this is the year when we will determine whether we shall *ever* catch up with the Reds. It's now or never. Certainly, the Russians won't be waiting for us to get on a par with them.

While Russia established a Commission for Astronautics several years ago, giving her a comfortable lead in the race for space weapons, complacency and ignorance have delayed our missile progress. We have been complacent in refusing to believe we were in a race with Russia. We showed our ignorance when we thought it inappropriate to use military rockets to bring aloft "civil" satellites "merely" to serve science.

We now know that the Russians employed their most powerful Army rockets to send aloft their Sputniks. Russia's ability to put up an 1100-pound satellite is indicative that the Reds are advanced in the art of ballistic missiles. Intelligence received in this country during the last two years, that the Reds have intermediate-range ballistic missiles in mass production, is now fully accepted.

Our missile concept and time table have been upset by Russia's advances. And our military planners must understand this. We cannot continue the approach of trying to match or obtain the equivalent of an opponent's weapons arsenal and striking power. Simply equaling him nets nothing but an expenditure of resources to achieve no appreciable gain.

What must be done is to aim not for an equal, but a far reaching and more important objective. Simply matching Russian accomplishments will not reclaim U.S. prestige in the eyes of the world, nor will it reinstate us as the world's leading power.

If we could only eliminate inter-service rivalry squabbles much would be gained. In fact, we could leapfrog the Russians by employing some rather unusual, coordinated mergers of weapons systems. Instead of the Navy mothballing its carriers and the Air Force scrapping missiles like the *Snark,* we could achieve immediate and truly potent deterrent striking power by marrying the systems. Three aircraft carriers each equipped with two squadrons of *Snarks*—operating in the Atlantic, the Pacific and the Mediterranean waters—would give us an almost unparalleled intercontinental missile striking capability.

The *Snark* is our only proven long-range missile. It is successful. It can be employed as a low-altitude mass-attack weapon. A whole group of *Snarks* could be launched within minutes from the deck of a carrier. It is ready now. According to Navy sources a carrier *Snark* system could be activated in less than six months. It would stun the Russians. It would restore our prestige and help us rebuild the deterrent capability we once had.

Carriers are slow. But they are on the move. And mobility is the top parameter in missile efficiency. This, of course, is the main reason for Russia's emphasis on missile-carrying submarines. Here's our chance not only to match them, but to bypass them, since our *Snarks* have intercontinental range.

True, a carrier-based *Snark* is not a lasting weapons concept. But it most certainly would help us get into operation a truly sophisticated missile system now—during the two-to-three year interim period while awaiting operational ICBMs and their complex bases and other space weapons.

ERIK BERGAUST

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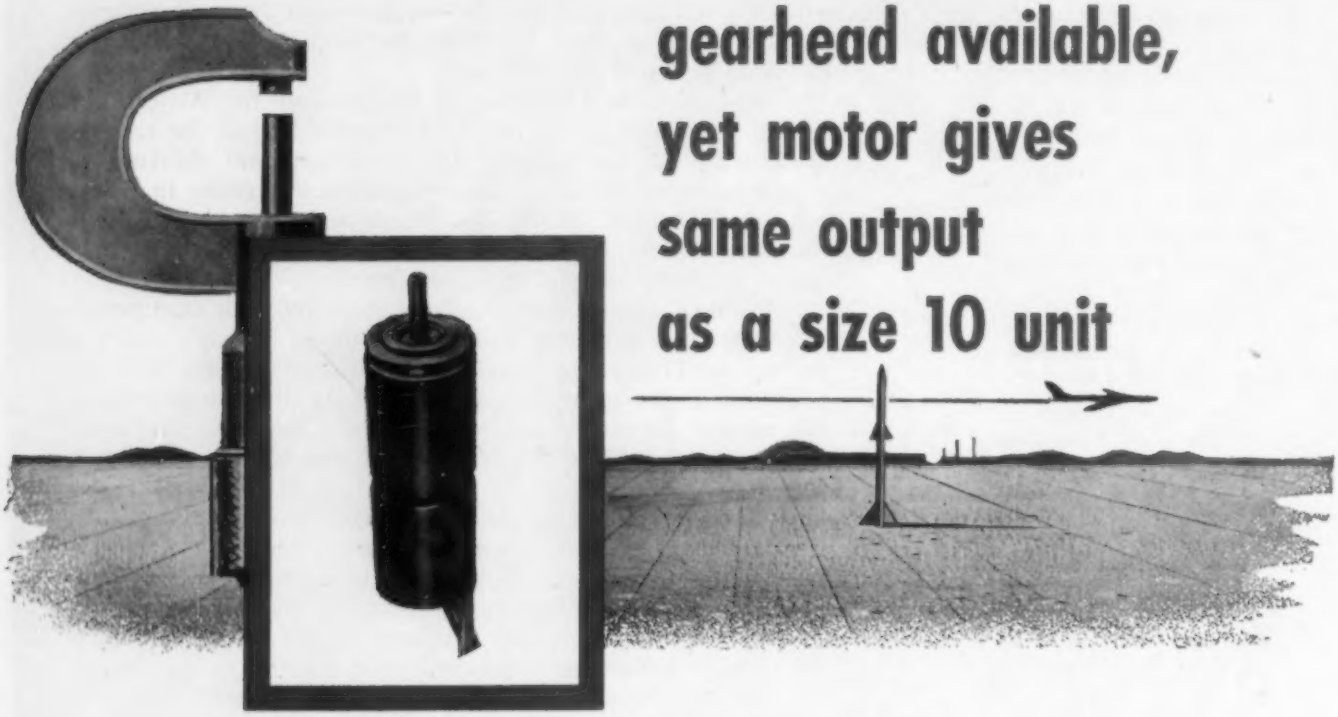

OPERATING CHARACTERISTICS:

- Type of motor: Two phase
- No load speed (Min. R.P.M.): 6200
- Stalled torque (Min. in. oz.): 0.20
- Power input at stall (Nom. watts/phase): 1.7
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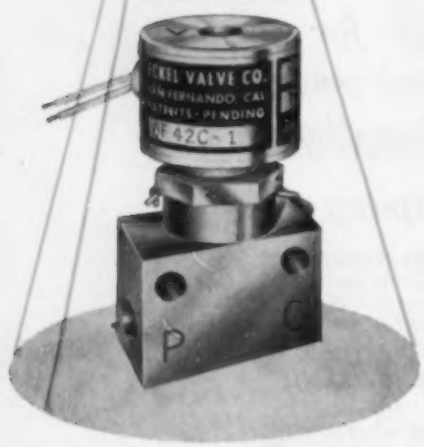

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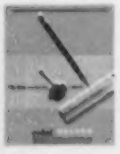

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letters

Small Tracks Overlooked

To the Editor:

With reference to Mr. Alfred Zaehringer's statement in "Rocket Sled Experiments" published in a recent issue of m/r, there are five and not four smaller tracks in the United States. A fifth track is located at the Naval Air Development Center, Johnsville, Pa. This track is 750 feet long. The sled is rocket-propelled and pneumatically decelerated. Its design maximum is 100 g's and its payload is small (less than 100 lbs.).

The larger rocket tracks are certainly valuable and possibly more glamorous than the smaller ones. The small tracks, however, are capable of filling a need in the development of missile components.

Richard Scharmann
U.S. Naval Air Development Center
Aeronautical Electronic and
Electrical Lab.
Johnsville, Pa.

Red Book Unavailable

To the Editor:

In a recent "Soviet Affairs" column, Dr. Albert Parry mentioned BOR'BA V EFIRE (STRUGGLE IN THE AIR) by Aleksandr Beliayev, a Russian novel issued in 1928 picturing a future Soviet-American war. I wonder if it would be possible for me to purchase or otherwise obtain a copy of this.

Allow me to compliment Dr. Parry on his prediction on *Sputnik* as well as on his excellent column.

Roy E. Licklider
Mayer, Ariz.

In answer to numerous inquiries about the Russian novel on the Soviet-American rocket-and-death-ray war of the future, Dr. Parry informs us that the novel is not readily available now, either in its Russian original or in his English translation. Dr. Parry has recently completed his translation of the book but it has not yet been published.—Ed.

Naval Commander Comments

To the Editor:

On reading the Vaeth-Huson article "Training Potentialities of Synthetic Missiles" in m/r, we of the U.S. Naval Guided Missiles School, Dam Neck, Va. ran the entire gamut of emotions:

Agreement—with the idea that synthesis has a big place in the training of missilemen.

Shocked disbelief—at what we feel certain was an unintentional slur on the manufacturers' reliability control and on the supervisory abilities of instructors.

Query—as to where the "experience" of early component failure and extent of down time was gathered. (Certainly not from us who train on the equipment.)

Relief—on reading the footnote wherein the authors admit the ideas propounded are neither those of the Navy Department nor the Naval establishment at large.

Cloud Five is a fine place to work from, but let's not get up to Cloud Nine or we will spend more on synthetics than on the usable—and reusable weapon!

Alex. A. Sproule
Commander, USN
Officer in Charge
U.S. Naval Guided Missiles School
Dam Neck, Va.

Mighty Mouse Shared

To the Editor:

. . . I am sure you have heard by now that *Mighty Mouse* should have been listed as a Navy-Air Force rocket. Its design was developed at the Naval Ordnance Test Station of the Navy's Bureau of Ordnance at Inyokern and the first prototypes were manufactured there. Practically all of the initial test work, both ground and air firings, was done there. It was first adopted for service use on naval aircraft and somewhat later by the Air Force. The contracting for production, and the inspection of the great number of rockets manufactured, were handled entirely by the Navy, Bureau of Ordnance. It is true that the quantities eventually delivered to the Air Force were considerably greater than those for naval aviation because the Air Force has more fighters than the Navy has . . .

M. F. Schoeffel
Rear Admiral, USN (Ret.)
611 Wyatt Building
Washington 5, D.C.

Sorry. We'll make sure the Navy gets proper credit when we cover the Mighty Mouse *in the future.—Ed.*

Likes Our Stand

To the Editor:

I have just read your m/r for the first time and find it to be extremely frank and exhilarating. If a publication can have "guts," yours does.

It is the first publication I have ever read from cover to cover at one sitting. If it were read on all levels in Washington I am certain it could be one of the biggest single contributions to our defense effort.

Howard G. Gillette,
Chief Chemist
Precision Rubber Products Corp.
3110 Oakridge Drive
Dayton 7, Ohio

m/r Stands Corrected

To the Editor:

A letter to the editor in your December issue asked m/r for developments in the air-to-surface missile field. An editorial comment followed that the U.S. does not have much of a "sophisticated" program in this field and that other than Bell's *Rascal* and the new North American ASM, m/r didn't know of any new developments.

I hasten to add that The Martin Co.'s *Bullpup* is a new development, and we believe it is sophisticated.

Don Perry
Information Services
The Martin Co.
Orlando, Fla.

To the Editor:

A little problem of ours—and we would appreciate your help.

Publications often refer to our firm as AS&R. That's wrong; it can be confusing to readers and embarrassing to us.

Like many people we have two "names," the formal and familiar (William Smith and Bill Smith). Ours are: American Smelting and Refining Co., or simply Asarco.

Jackson How
American Smelting and Refining Co.
120 Broadway
New York 5, N.Y.

Circle No. 89 on Subscriber Service Card. ——→

200° F

500° F

1000° F

2000° F

HEAT RESISTANT...

At aircraft firewalls or in guided missiles... wherever high temperatures are encountered ...you can get full protection by using Cannon Steel Shell High Temperature Connectors to protect electrical circuits.

MS-K receptacle with crimp-type contacts

FW-23 plug, either crimp or solder-pot contacts

FWR-31SL wall mount receptacle, socket insert

FWR-22 plug, pin insert assembly

Cannon Electric supplies both MS-K and FW fireproof types of electrical connectors for the protection of vital circuits in flame barrier applications.

The fireproof test of Military Specification MIL-C-5015 assures that a connector will carry a specified current for 5 minutes and prevent the passage of flame for twenty minutes while being subjected to a flame of 2000°F. Cannon MS-K Connectors meet this specification.

In addition to firewall plugs Cannon Electric has developed connectors that operate continuously up to 1000° F. Developments are under way that will increase the temperature range. We would like to suggest that you will find it well worth your while to consult our engineering personnel for full information on the newest high temperature connectors available.

For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

Please refer to Dept. 438

More than 27,000 Cannon Connectors assure you the opportunity of selecting exactly the right connector for any particular application you have in mind. Please write for new 44-page, 2-color Cannon Plug Guide, Bulletin CPG-3.

CANNON PLUGS

WHERE RELIABILITY IS THE 5TH DIMENSION

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, California. Factories in Los Angeles, Salem, Mass., Toronto, Melbourne, London. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities. See your Telephone Yellow Pages.

CANNON ELECTRIC

LATITUDE 58—ALTITUDE 200

The International Geophysical Year is a period of intensive study of the earth and its atmosphere—an all-out cooperative effort of American science and industry.

During IGY, Aerojet-General's Aerobee-Hi research rockets will focus a scientific eye on the ionosphere, 200 miles over Ft. Churchill, Canada. The data obtained will make invaluable contributions to aerodynamics, aeromedicine, and the physical sciences.

Aerojet's Aerobee has been synonymous with all-weather reliability and low-cost atmospheric research for over a decade.

Aerojet-General CORPORATION

A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

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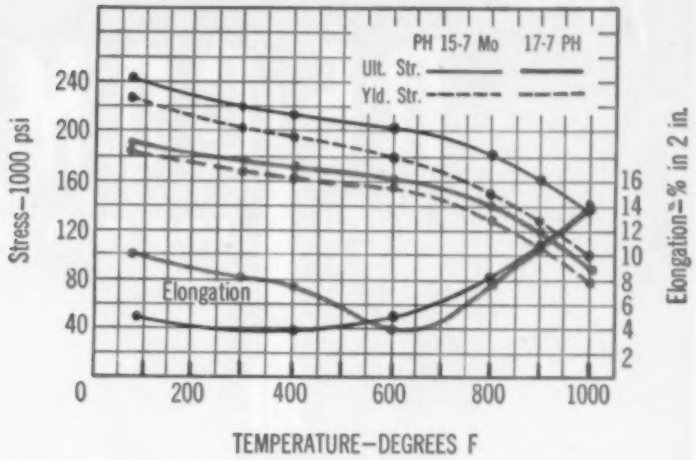
THE GENERAL TIRE

NEW HIGH STRENGTH STAINLESS FOR MISSILES

Offers guaranteed F_{tu} for sheet of 225,000 psi, high strength-weight ratios to 1000 F, excellent workability, and is available in all forms.

Typical short-time tensile properties at elevated temperatures

PH 15-7 MO (Cond. RH 950)—17-7 PH (Cond. TH 1050)



Armco PH 15-7 Mo is a new stainless steel specifically developed for missiles and supersonic aircraft. Commercially available in all forms, it supplements and offers even greater design advantages than Armco's 17-7 PH and 17-4 PH Stainless Steels that are now used extensively in intermediate and long range missiles.

Design and Production Advantages

Tensile properties at elevated temperatures indicate the possibilities of PH 15-7 Mo for minimum-weight structures that withstand heat. This new missile material offers unusually high strength-weight ratios at temperatures up to 1000 F and good corrosion resistance. These properties make Armco PH 15-7 Mo ideal for structural components, fuel system tanks, valves, pumps and other accessory parts.

Excellent fabricating characteristics insure producibility of PH 15-7 Mo parts. Standard production methods may be used because the material can be fabricated in the easily-worked annealed condition, then hardened by a simple heat treatment.

Additional Data Available

Look into the multiple advantages offered by this new Armco Stainless Steel in the design and production of missile components. For complete information on its properties, heat treatment, and fabrication, fill out and mail us the coupon.

ARMCO STEEL CORPORATION, 1328 Curtis St., Middletown, Ohio

Send me information on Armco PH 15-7 Mo Stainless Steel

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COMPANY_____

STREET_____

CITY_____ ZONE_____ STATE_____

ARMCO STEEL

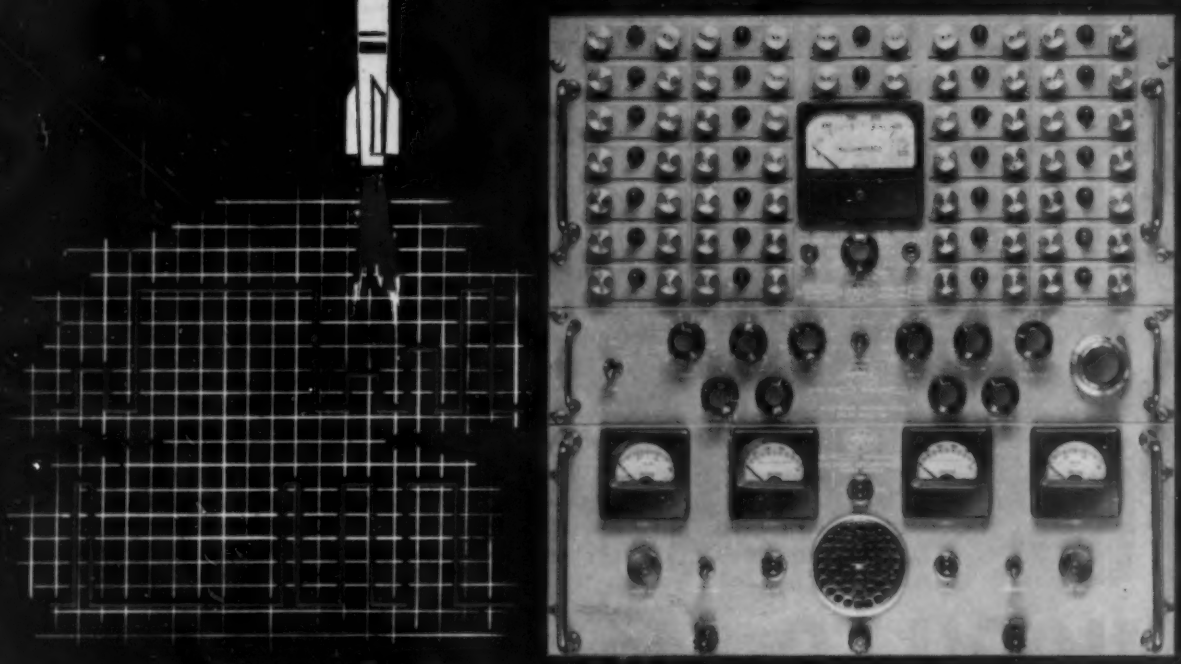
ARMCO STEEL CORPORATION, 1328 CURTIS STREET, MIDDLETOWN, OHIO

SHEFFIELD DIVISION • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION

New.... ARNOUX miniature

DECOMMUTATOR

FOR PAM and PDM TELEMETRY SYSTEMS



The new Arnoux Model TDS30-1 Decommutation System is completely self-contained within three chassis assemblies consisting of: Gating Unit (TOP), Pulse Selector (MIDDLE) and Regulated Power Supply (BOTTOM). The unit handles 28 channels of information and occupies only 19½ inches of panel height in a standard relay rack. Overall depth behind panel is 13 inches.

WRITE FOR
ARNOUX BULLETIN 800

The Arnoux Model TDS30-1 Decommutation System is compactly designed for use in airborne or trailer installed telemeter receiving stations and in portable check-out equipment.

- Miniaturization is the natural result of a new circuit design allowing the entire system to contain only 76 tubes as opposed to several hundred in competitive systems.
- Modular construction permits easy expansion of system to any desired channel capacity.
- Novel circuitry design does not reflect errors due to center frequency drift of sub-carrier oscillators, drift of discriminator D. C. output level, or tape playback speed errors.
- Built-in test selector permits visual inspection of waveforms throughout system for quick malfunction detection.
- Neon indicators on each gating unit give continuous visual indication of correct sequential operation.
- System accepts all standard IRIG inputs, either PAM or PDM, at any sampling rate from 75 to 900 per second.
- Overall linearity is within ± ½ % at maximum level. Long term level drift is within ± ½ %. Gain drift is negligible.
- Modular plug-in gating units allow quick replacement of faulty channels.
- Two spare units are maintained on standby for instant use.
- Power required is 115 volts, 60 cps, single phase. Optional 115 volt, 400 cps, power supply available for airborne application.

ARNOUX

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announcing CEC's new

airborne **DataTape** *system*

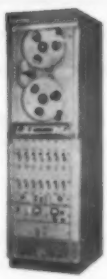
DATATAPE RECORDER

CEC's *all new Type 5-702* provides up to 14 tape tracks, instant selection of tape speed, with large capacity of ½" or 1" tape on 10½" reels. The mounting of reproduce headstacks permits downstream monitoring of all tracks coincident with the collection of data, also converts the Recorder to a ground laboratory playback machine.

NEW MINIATURIZED ELECTRONICS

Record Amplifiers—Seven record amplifier plug-in modules can be housed in a single amplifier case—the smallest package on the market today. 10-20 oz. modules (6¼" long by 3¼" high and 1-3/16" wide) provide FM, PDM, or Analog recording. No shockmount is required. Write for following bulletins:
Analog, Bulletin CEC 1592-X2.
PDM, Bulletin CEC 1594-X2.
FM, Bulletin CEC 1595-X2.

Power Supply weighs only 17 pounds. Only one unit is required to supply any combination of 14 record amplifiers. No shockmount is required.



5-752 Recorder/ Reproducer

Continuous Loop Transport

Now, for the first time, you can get precise magnetic tape data at extreme altitudes and temperatures to 100°C—performance guaranteed by the most compact airborne system available today. DataTape's unique combination of advantages include outstanding miniaturization, all metal-surface magnetic heads, and rugged, modular construction. No shockmounts are required. The new airborne system is completely compatible with CEC's 5-752 Recorder/Reproducer. *Contact your nearby CEC field office for complete information, or write for Bulletin CEC 1607-X2.*

Compare these features:

- **ALL-METAL-SURFACE MAGNETIC HEADS**
- **DESIGNED FOR HIGH-TEMPERATURE OPERATION**
- **CAST ALUMINUM ALLOY CONSTRUCTION**
- **MINIATURIZED—MODULAR DESIGN**
- **SIX TAPE SPEEDS . . . ELECTRICALLY SELECTED WITHOUT BELT CHANGES**

DataTape Division

Consolidated Electrodynamics

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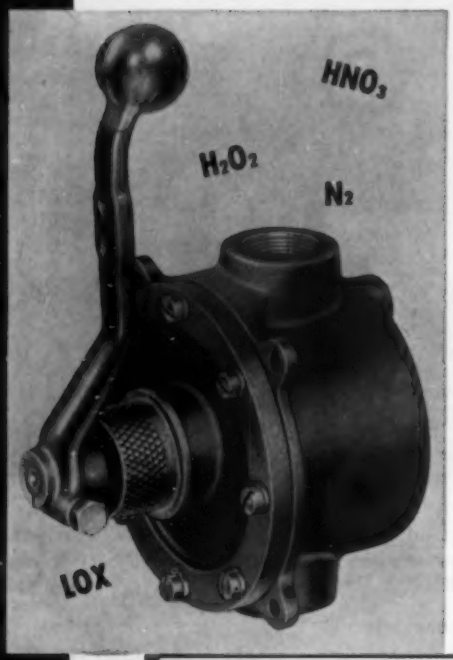
UAP pumps provide safe, easy transfer of...

Liquid Missile Fuels and Oxidizers!



Liquid fuels and oxidizers are tricky to handle. They are cold, lethally poisonous, often corrosive! UAP offers a hand-operated pump now fortified against corrosion with compatible metals, metal coatings and seals. The pump provides safe and easy handling of liquid missile fuels and oxidizers in labs, testing areas and launching sites.

These high performance, positive displacement pumps are of the oscillating vane type. A simple design features gravity and pressure operated valves that provide positive fluid control—even up to angles of 20 degrees from the vertical. Pumps are self-priming and can be easily installed for either right or left hand operation.

The unusual durability of these compact, portable, lightweight pumps may help solve your handling of LOX, fuming nitric acid, peroxide, liquid ozone, flourine, and other production or experimental missile liquid fuels and oxidizers.

PERFORMANCE DATA			
DISCHARGE—GPH	up to 150.0	INLET PRESSURE—psia	12.7
DISCHARGE PRESSURE—psia	up to 54.7	STATIC TEST PRESSURE—psia	up to 134.7

Write for complete information . . . or submit your application problem today for UAP design study! Call or write the nearest UAP Contractual Engineering Office listed below!

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ONCE AGAIN ELECTRONIC COMPUTATION AT WORK HELPS RESOLVE A VITAL PROBLEM

Freezing enemy air assaults at "real time" speed—if and when they should come—is a must of modern defense. And high speed computation applied through a System Study makes this possible.

Suppose, for example, enemy air armadas are jetting in on target from several "o'clocks" at once. How do we gauge their speed, location and relative priority . . . then assign the best available weapon to obtain the kill?

The U.S. Army Signal Corps handed Burroughs Corporation this objective. We examined the military problem and developed a tactical analyzer known as MATABE (Multi-weapon Automatic Target and Battery Evaluator). Using MATABE, Burroughs Corporation is continuing this System Study which will determine the ultimate defensive weapon system.

In such System Studies, again you see Burroughs at work, analyzing and resolving problems for the military—and for civilian industry, too.

Inquiries for further System Studies are welcomed in any and all areas of our proved competence. Write, call or wire Burroughs Corporation, Defense Contracts Organization, Detroit 32, Michigan.

BURROUGHS CORPORATION

THE FOREMOST NAME IN COMPUTATION

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Now...a battery of Hydroforms at

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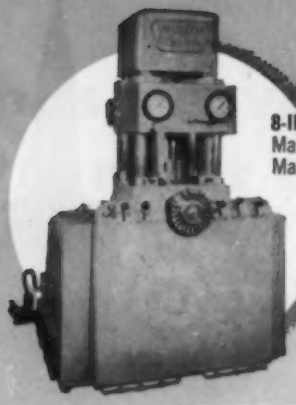

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Maximum Blank — 8" Diameter,
Maximum Draw Depth — 5"

— to reduce your development time and costs on every pre-production run!

Kaupp hydroformed prototypes and pre-production parts are accurately formed and drawn in less time, at lower cost. Hydroforming produces short run, and in some cases production pieces, quicker and more economically than tool and die methods. New equipment installed by Kaupp assures faster service. For complete information on Kaupp metal forming facilities, call or write today!

- FEWER DRAWING OPERATIONS
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Expanded Kaupp facilities include deep drawing by conventional methods for volume production runs and a completely equipped metal spinning department.

19-INCH HYDROFORM
Maximum Blank
19" Diameter
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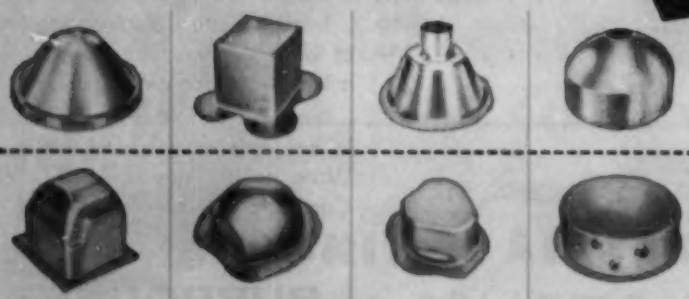
Depth — 8"

Specify KAUPP...
for Accurate Forming and Drawing of Stainless Steel, Inconel, Cold Rolled Steel, Aluminum, Copper, Brass and Other Alloys



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NEWARK WAY • MAPLEWOOD
NEW JERSEY

12-INCH HYDROFORM
Max. Blank — 12" Diameter
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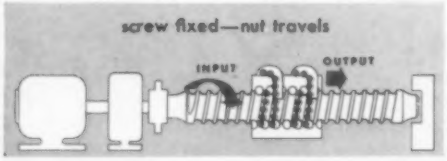
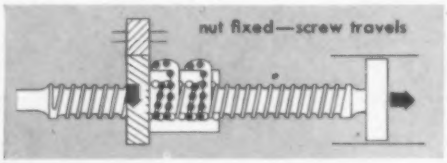
Here's your new ANSWER

PHOTOGRAPHED ACTUAL SIZE
BALL CIRCLE DIAMETER: 3/16 inch.

WORLD'S SMALLEST ball/bearing SCREW SOLVES CRITICAL MINIATURE POSITIONING/CONTROL PROBLEMS



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque than acme screws.



SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with unprecedented efficiency.

An unprecedented achievement in minimum size and weight—maximum efficiency, dependability and service life for ultra-precise controls.

It's another first from Saginaw—and the possibilities it opens up for improved electrical and electronic controls are limited only by your imagination! Radar tuners, missile and rocket guidance and telemetering systems, automatic switchgear, electronic machinery controls are just a few of the applications where this new miniature Saginaw b/b Screw will solve critical positioning/control problems. *It's so compact and light,* you can save substantially on space and weight. *It's so efficient,* (over 90%) you can use much smaller motors and gear boxes. *It's so precise,* you can position components within .0005 inch per inch of travel. *It's so dependable,* you can rely on remarkably long service life even in adverse environments.

You will find our 1958 Engineering Data Book extremely helpful in planning applications, or experienced Saginaw engineers will gladly make specific recommendations without obligation. Just phone, write or mail the handy coupon.

Saginaw

ball bearing Screw

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. . . a reputation for integrity, for quality and service . . . for advanced creative engineering achieved by New Departure in over half a century of precision ball bearing manufacture.

You'll find this emblem is also symbolic of our determination to continue, in the fullest measure, all those factors which have built that reputation. It is a visual pledge of this resolution to all our customers, present and future.

turning point of modern industry

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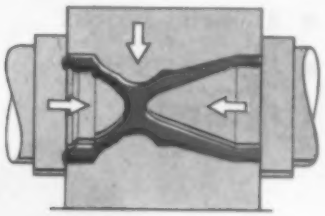
DIVISION OF GENERAL MOTORS—BRISTOL, CONN.

NO WONDER WE MAKE SO MANY

CAMERON ONE PIECE FORGED MISSILE NOZZLES

1. Have no welds
2. Require less machining
3. Are lower in cost

A better nozzle for less money has put Cameron way ahead in production of these important missile parts. Cameron's exclusive split-die forging process makes this possible. Each nozzle is forged from a single heated billet of specified steel. This steel is produced in Cameron's own melt shop under the closest possible control. From these perfect billets our specially designed split-die presses forge a near final shape.



Movement of the three elements in the split-die process.

No welds are required and machining is greatly simplified—grain structures are perfect.

Missile nozzles produced by this method are supplied as finished forgings ready for economical machining or completely machined to specification. At every single phase of manufacture, each nozzle is checked by the most modern methods used today.

The Cameron split-die process has successfully solved many unusual forging problems in a wide variety of end uses. Some of these include critical airframe members, jet engine components, propeller blades and hubs, atomic reactor valves and many high pressure controls for the oil industry.

Cameron has extended the great advantage of ferrous forged members to include shapes impossible to produce heretofore. Present production of missile nozzles includes diameters to 28″ with large open sections and elongated double conical thin sections to 36″ in length. In weight our forgings range to 8,000 lbs. and our high quality alloys satisfy many unusual demands. If you need forgings in this group and, of course, if you need nozzles, call, write or come by . . .

Cameron
IRON WORKS, Inc.
SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

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For Extreme Temperatures *Plus* Perfect Seal

MARMAN

CONOSEAL

- HIGH PRESSURE PNEUMATIC SYSTEMS
- LIQUID OXYGEN SYSTEMS
- HYDRAULIC SYSTEMS
- EXHAUST SYSTEMS
- FUEL SYSTEMS

Problems of connecting tubing and ducting of dissimilar metals subject to extreme temperatures can be solved with the new Marman Conoseal Tubing Joint. An all-metal joint, it provides metal gasket compression with the flexibility and sealing qualities formerly obtained only through use of organic seals. The Conoseal Joint withstands linear deflections up to 1/16-inch without sacrificing a perfect seal.

The seal is maintained under extreme pressures and temperatures even on joints with material transitions, in which steel and aluminum alloy plumbing are joined.

The Conoseal Tubing Joint is available in three different operating performance ranges to meet varied applications. Standard sizes from 1" to 12" O.D. tube size, with special sizes designed to your requirements. Write today for full engineering details.

Operating Range	Temperature Range (°F.)	Max. Pressure (3" Size @ 70°F.)
Low	—300 to +750	1300 psig.
Medium	—300 to +1000	3300 psig.
High	—300 to +1800	6000 +psig.

Conoseal is an Aeroquip Trademark

MARMAN DIVISION
Aeroquip Corporation

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MARMAN PRODUCTS ARE MANUFACTURED UNDER VARIOUS U. S., CANADIAN AND FOREIGN PATENTS AND OTHER PATENTS PENDING

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. . . missile handling is faster, more precise with hydraulic power by VICKERS

Looking for a better drive to Move missiles from storage to launchers . . . to Aim missiles precisely . . . to Guide or Track missiles? Then consider these features of a Vickers hydraulic drive:

Ultra fine control — missile launchers and radar drives have been trained and elevated with exceptional accuracy down to speeds approaching zero.

Fast positioning — the fastest acceleration, deceleration and reversal of any power transmission.

High power gain — one milliwatt input easily controls hundreds of horsepower.

Narrow deadband — narrower than any other high horsepower drive.

Excellent efficiency — overall mechanical efficiency of hydraulic transmissions (motor and pump) can exceed 85% at full load.

Consider, too, these other advantages — unusual compactness . . . packaged units . . . extreme reliability.

If your missile handling problem is urgent, phone, wire or write for further information or an immediate visit by one of our application engineers.

For more than fifty years, we have worked on applications ranging from the largest gun turrets to missile launchers. So, tell us about your drive problem. There is an excellent possibility that we have already developed the units that will fit your needs.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Marine and Ordnance Department
WATERBURY 20, CONNECTICUT

Hydraulic Products for Marine and Ground Defense Applications

MO-212

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At the zero second everything must function without failure. ANDREW HELIAX cable is used in postassembly and preflight checkouts of missile radio frequency systems. The cable forms a closed circuit over which interrogation and response signals are transmitted between checkout equipment and airborne radio frequency packages. The HELIAX cable runs from a mobile trailer to connecting points on the missile.

The ruggedness of HELIAX makes it well suited to this challenging task, where its low VSWR, low RF leakage and low attenuation give accurate measurement of systems performance. Flexibility permits the cable to be taken down, recoiled and subsequently reused many times.

If you require similar characteristics in a cable, consider the special advantages of HELIAX.

HELIAX is normally supplied as an assembly, complete with end fittings factory attached, reducing installation labor and improving quality.

Complete uniformity throughout its entire length gives HELIAX *superior* electrical characteristics.

HELIAX is always less difficult, less costly to install, *easier to handle.*

HELIAX is available in 7/8"size (Type H0) and 1 5/8" size (Type H1).

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J. W. Marchetti, Director, Avco Electronics Research Laboratory

Pictured above is our new Research and Development Center now under construction in Wilmington, Massachusetts. Scheduled for completion in early 1958, this ultramodern laboratory will house the scientific and technical staff of the Avco Research and Advanced Development Division.

Avco's new research division now offers unusual and exciting career opportunities for exceptionally qualified and forward-looking scientists and engineers in such fields as:

Science:
Aerodynamics · Electronics · Mathematics · Metallurgy
Physical Chemistry · Physics · Thermodynamics

Engineering:
Aeronautical · Applied Mechanics · Chemical · Electrical
Heat Transfer · Mechanical · Reliability · Flight Test

Write to Dr. R. W. Johnston, Scientific and Technical Relations, Avco Research and Advanced Development Division, 20 South Union Street, Lawrence, Massachusetts.

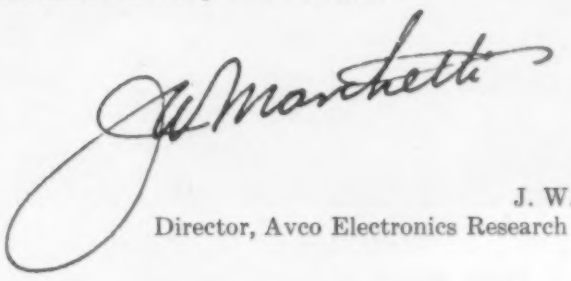
Circle No. 6 on Subscriber Service Card

CREATIVITY

If there is a single word that can best describe the aim and purpose of AVCO's Research and Advanced Development Division, it is creativity. We at AVCO have assembled those elements and that atmosphere which we believe are most conducive to true creative effort.

Our future progress depends on an early recognition of the difference between an *important* new idea and just a new idea. It is mere quibbling with words whether we call these things new discoveries, breakthroughs, or basic research. They are, in fact, merely the signposts of our future. The world in 1980 and the year 2000 will, in its technological aspects, be vastly different from what we know today. Yet locked somewhere on our present scientific frontiers is the knowledge that will spell out this difference. It is our purpose to help in the unlocking of that knowledge and to contribute our part to the over-all progress.

The most important ingredients of creativity are curiosity and a real will to work hard. Of only slightly lesser importance is the feedback, or close working relationship between theoretician and observing experimentalist. We at AVCO also realize that a single creative effort is the output of a man, or, at the most, of a small group of men at any one time. It is, therefore, continuously subject to the criticism of other men and some even more stultifying forces. Some of these are economic or organizational and others are of a more subtle variety. We of the AVCO management consider it our responsibility to be alert to both positive and negative factors affecting creativity. We consider the ability of our men to create for the future, the most important function of the AVCO Research and Advanced Development Division.



J. W. Marchetti,
Director, Avco Electronics Research Laboratory

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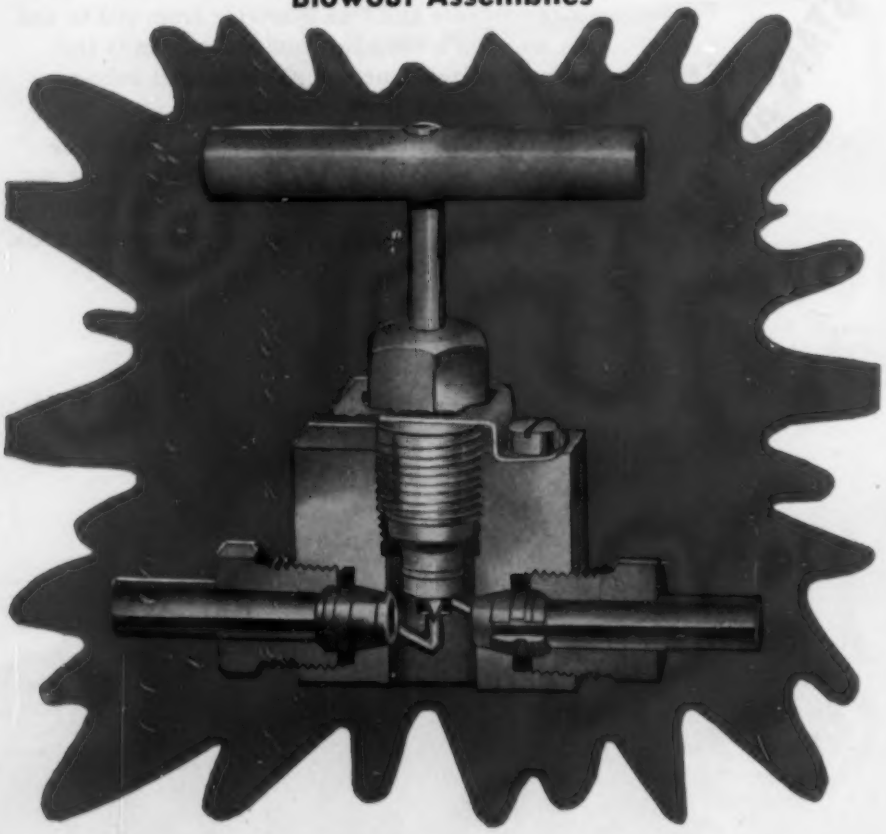

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FEBRUARY

"Are Flying Saucers Fact or Fancy?" Dr. Hugh Winn, Missile and Ordnance Systems Department, GE, Engineers Club, Philadelphia, Pa., Feb. 19.

MARCH

ASME Gas Turbine Power Division Conference and Exhibit, Shoreham Hotel, Washington, D.C., March 2-6.

1958 Nuclear Congress and Atomic Industry Trade Show, International Amphitheater, Chicago, Ill., March 16-22.

First Interservice and Industry Symposium on Guided Missiles Training Equipment (limited to those with secret clearance), Naval Ordnance Laboratory, Silver Spring, Md., March 18-19.

IRE, National Convention and Radio Engineering Show, Waldorf-Astoria Hotel, New York Coliseum, New York City, N.Y., March 24-27.

Fourth International Instrument Show, Caxton Hall, Westminster, London, March 24-29.

APRIL

ASME Division of Instruments and Regulators Conference, University of Delaware, Newark, Del., April 1-3.

Eighth International Symposium, Electronic Wave Guides, sponsored by Microwave Research Institute of Brooklyn Polytechnic Institute, Engineering Societies Building, New York City, N.Y., April 8-10.

ASME Maintenance and Plant Engineering Conference, Penn-Sheraton Hotel, Pittsburgh, Pa., April 14-15.

ASME Design Engineering Conference, International Amphitheater, Chicago, Ill., April 14-17.

ASME and AWS Engineering Division Joint Conference, Statler Hotel, St. Louis, Mo., April 15-17.

Institute of Environmental Engineers, Second Annual Technical Meeting, Hotel New Yorker, New York, N.Y., April 17-20.

AIEE, IRE, EIA, WCEMA Electronic Components Conference, Reliable Application of Component Parts, Ambassador Hotel, Los Angeles, Calif., April 22-24.

MAY

National Flight Test Instrumentation Symposium, Instrument Society of America, Park Sheraton Hotel, New York, N.Y., May 4-7.

Professional Group on Microwave Theory and Techniques, National Symposium, Stanford University, Palo Alto, Calif., May 5-7.

1958 Western Joint Computer Conference, Ambassador Hotel, Los Angeles, Calif., May 6-9.

Institute of Production Engineers, Production Exhibitions Conference, London, England, May 12-21.

JUNE

IAS, AIEE, ISA, National Telemetering Conference, Lord Baltimore Hotel, Baltimore, Md., June 2-4.

American Rocket Society, Semi-annual Meeting, Hotel Statler, Los Angeles, Calif., June 8-11.

ASME Semi-annual Meeting, Statler Hotel, Detroit, Mich., June 15-19.

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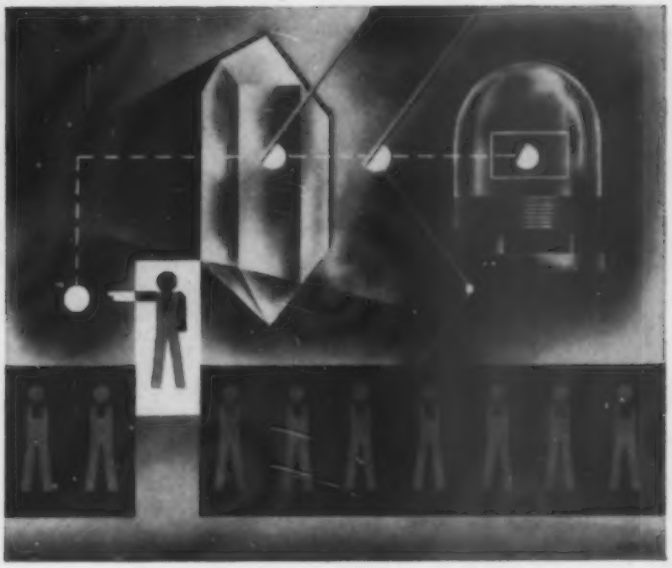

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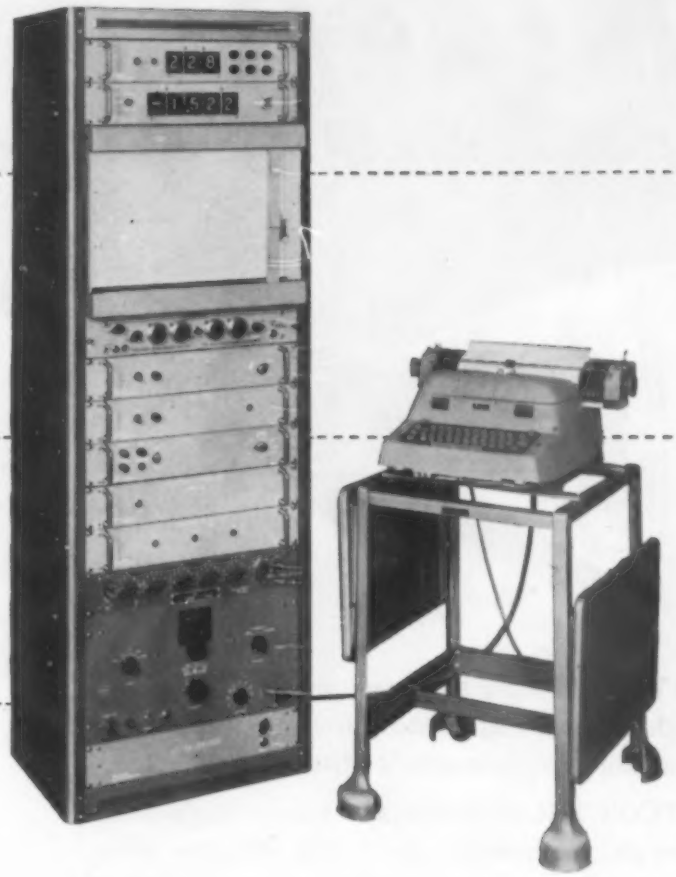

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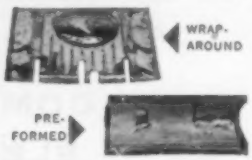

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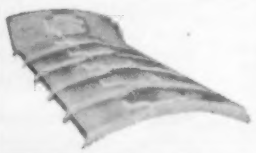

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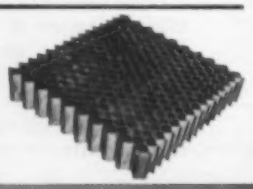

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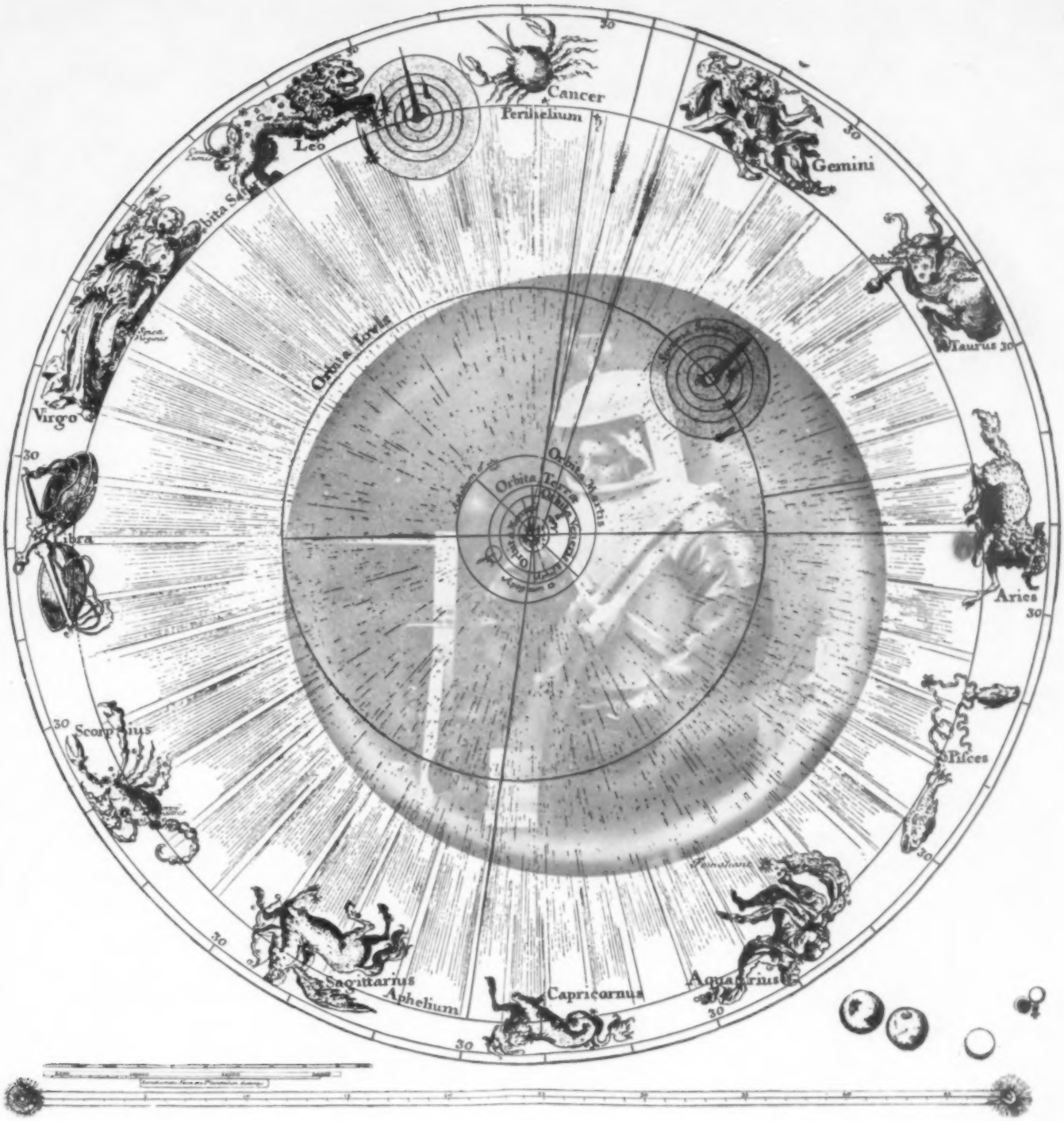

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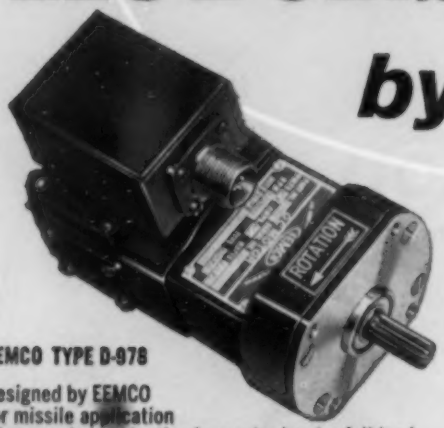
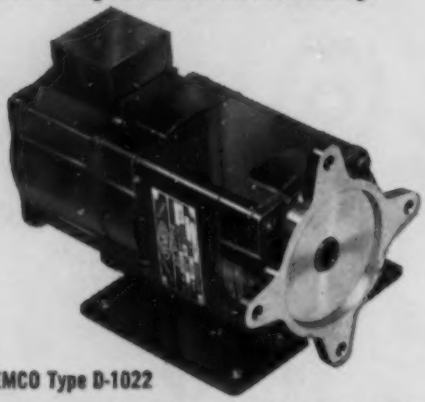


EEMCO TYPE D-978

Designed by EEMCO for missile application where prolonged testing is required under full load at a temperature range of +180° F. to +400° F. **SPECIFICATIONS: Volts:** 27 volts DC (24 to 32 volt range). **Horsepower:** ¼ HP (⅔ HP max. short time overload). **R.P.M.:** 12,000. **Weight:** 2.75 pounds. **Miltary Specifications:** Radio noise filter meets MIL-I-6181B. Explosion proof requirement meets MIL-5272A-Proc. 2. **Altitude Operation:** Tested successfully at over 200,000 feet altitude. **Features:** Built for high shock and vibration loading.

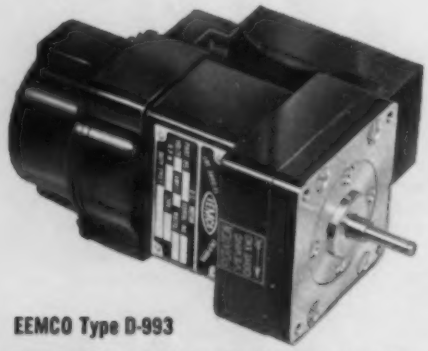
To design and produce motors for missiles that perform well beyond the limits of military specifications yet which maintain specified size and weight limitations is a constant objective at EEMCO. The design, development and testing of motors that achieve these extreme performance characteristics requires EEMCO to conduct company-financed independent research far beyond that normally conducted by a manufacturer of its size. In many instances EEMCO has been able to meet rigid specifications, in fact exceed them, when other producers have failed. For example, three of these extremely rugged new EEMCO motors illustrated will perform with reliability in the atmospheric conditions encountered at altitudes in excess of 200,000 feet, and they are built for unusually high shock and vibration loading. Please note the outstanding capabilities of the individual motors shown.



EEMCO Type D-1022

Designed by EEMCO for extremely high altitude operation with ambient temperature capacity to 165° F. Type D-1022 is capable of unusually high shock and vibration loading.

SPECIFICATIONS: Volts: 56 volts DC. **Horsepower:** 8.5 HP at 85% efficiency. **R.P.M.:** 12,000. **Duty cycle:** Two minutes. **Ambient temperature:** 165° F. **Weight:** 14.75 pounds. **Military Specifications:** Explosion proof requirement meets MIL-5272A-Proc. 2. **Features:** Built for high shock and vibration loading.



EEMCO Type D-993

Designed for missile applications where prolonged testing is necessary. Type D-993 will stand long idling periods with intermittent loads up to 1.25 HP. It is capable of withstanding vibrational accelerations of up to 125 "G's" in a frequency spectrum of 30 to 300 cycles per second.

SPECIFICATIONS: Volts: 28 volts DC (24 to 32 volt range). **Horsepower:** .65 HP. **R.P.M.:** 9600 RPM. **Weight:** 6.2 pounds. **Military Specifications:** Radio noise filter meets MIL-I-6181B. Explosion proof requirement meets MIL-5272A-Proc. 2. **Altitude Operation:** Tested successfully at over 200,000 feet altitude. **Features:** Built for high shock and vibration loading.

EEMCO Type D-899

Rated at 2.75 HP on continuous duty, EEMCO Type D-899 200-volt 400-cycle 3-phase motor is made with high temperature insulation allowing continuous operation at 3.5 HP or a correspondingly high ambient. D-899 contains an integral gear box.

SPECIFICATIONS: Volts: 200 volts, 400 cycle, 3-phase. **Load:** 2.75 HP continuous duty. **R.P.M.:** 3140 RPM. **Power Factor:** 83%. **Overall Efficiency:** 76% for entire unit including gear box. **Military Specifications:** Meets MIL-M-7969A (ASG). **Weight:** 11.25 pounds. **Features:** Type D-899 may be made splash- and drip-proof with minor alterations. Gear box, acting as motor support, places base at approximately the center of gravity of a motor-pump assembly thereby limiting extreme shocks and vibrations encountered in a missile.

EEMCO HAS DESIGNED and produced motors and actuators for missiles and aircraft exclusively for the past 15 years. It has made nothing else. Exhaustive research and testing aimed at perfection in the art of building these units has been a constant objective since EEMCO was founded. As a result, extreme precision and reliability has been attained in its products; therefore many of the latest missiles and aircraft being developed and manufactured for our Armed Forces today contain EEMCO motors and/or actuators.

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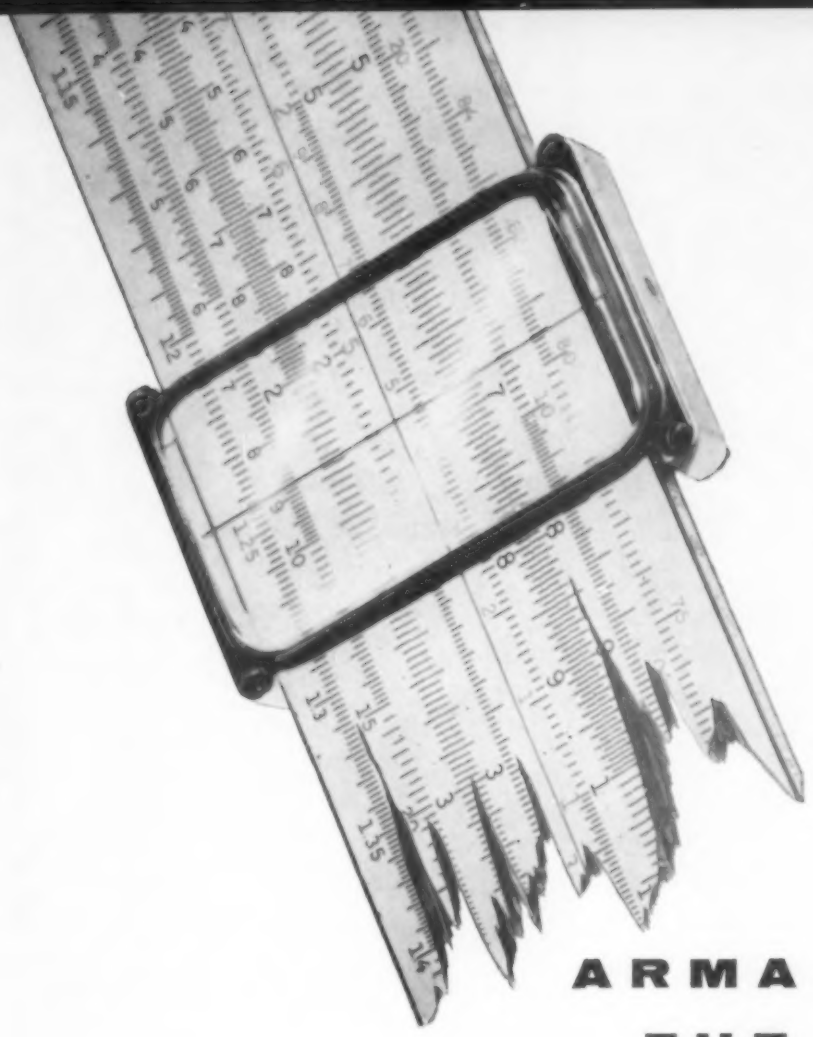

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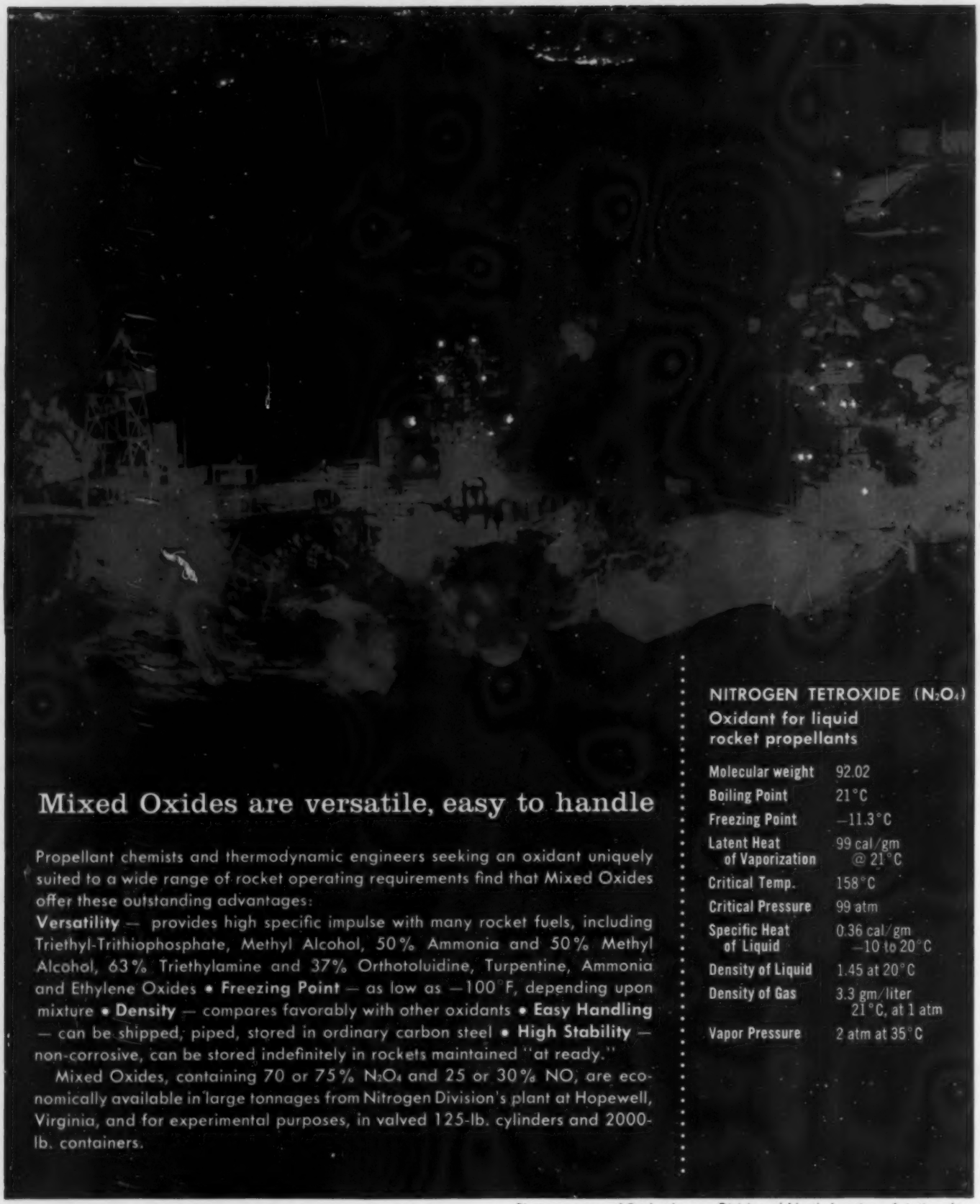

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Critical Pressure	99 atm
Specific Heat of Liquid	0.36 cal/gm —10 to 20°C
Density of Liquid	1.45 at 20°C
Density of Gas	3.3 gm/liter 21°C, at 1 atm
Vapor Pressure	2 atm at 35°C

Photo courtesy of Pocketdyne, a Division of North American Aviation, Inc.

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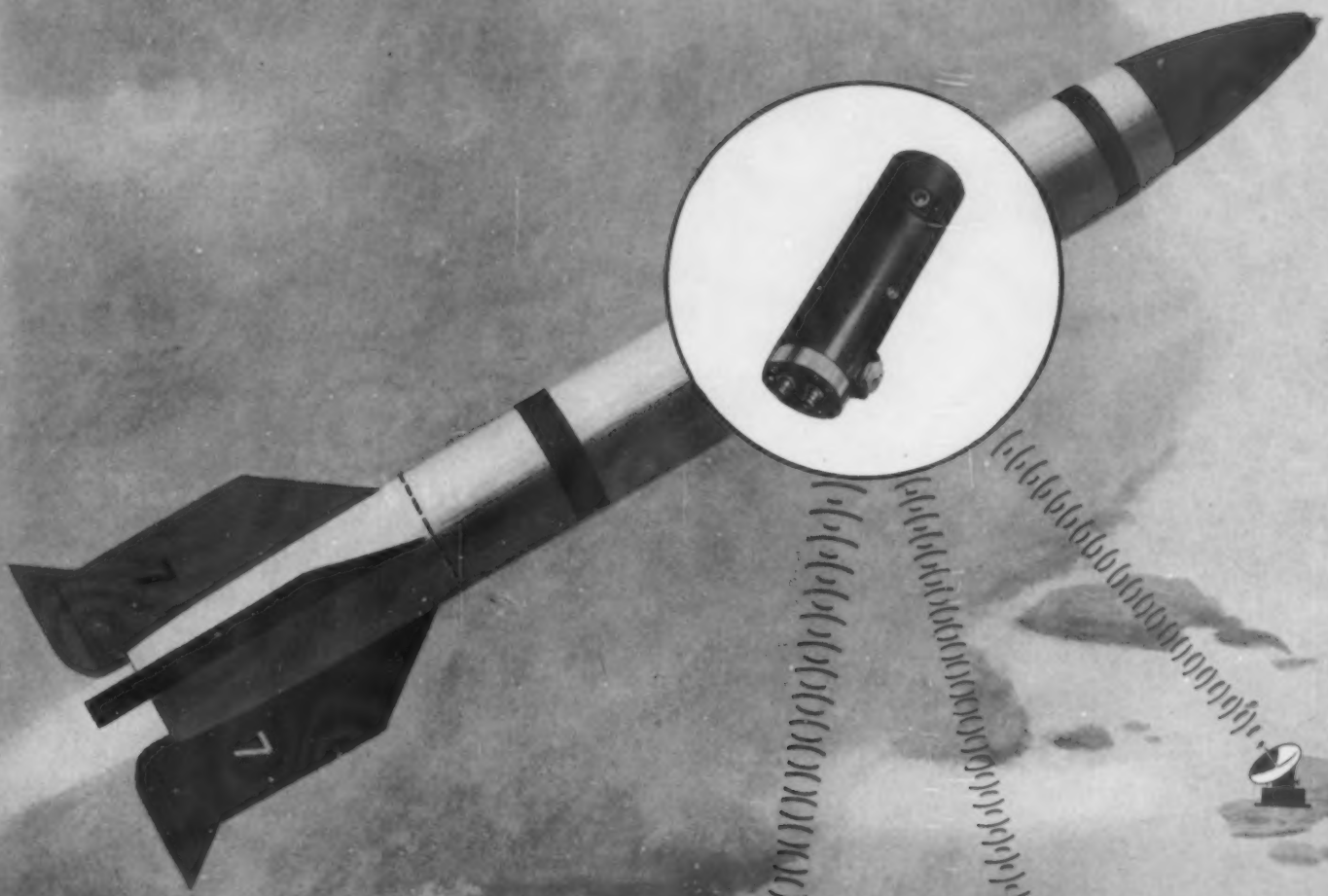

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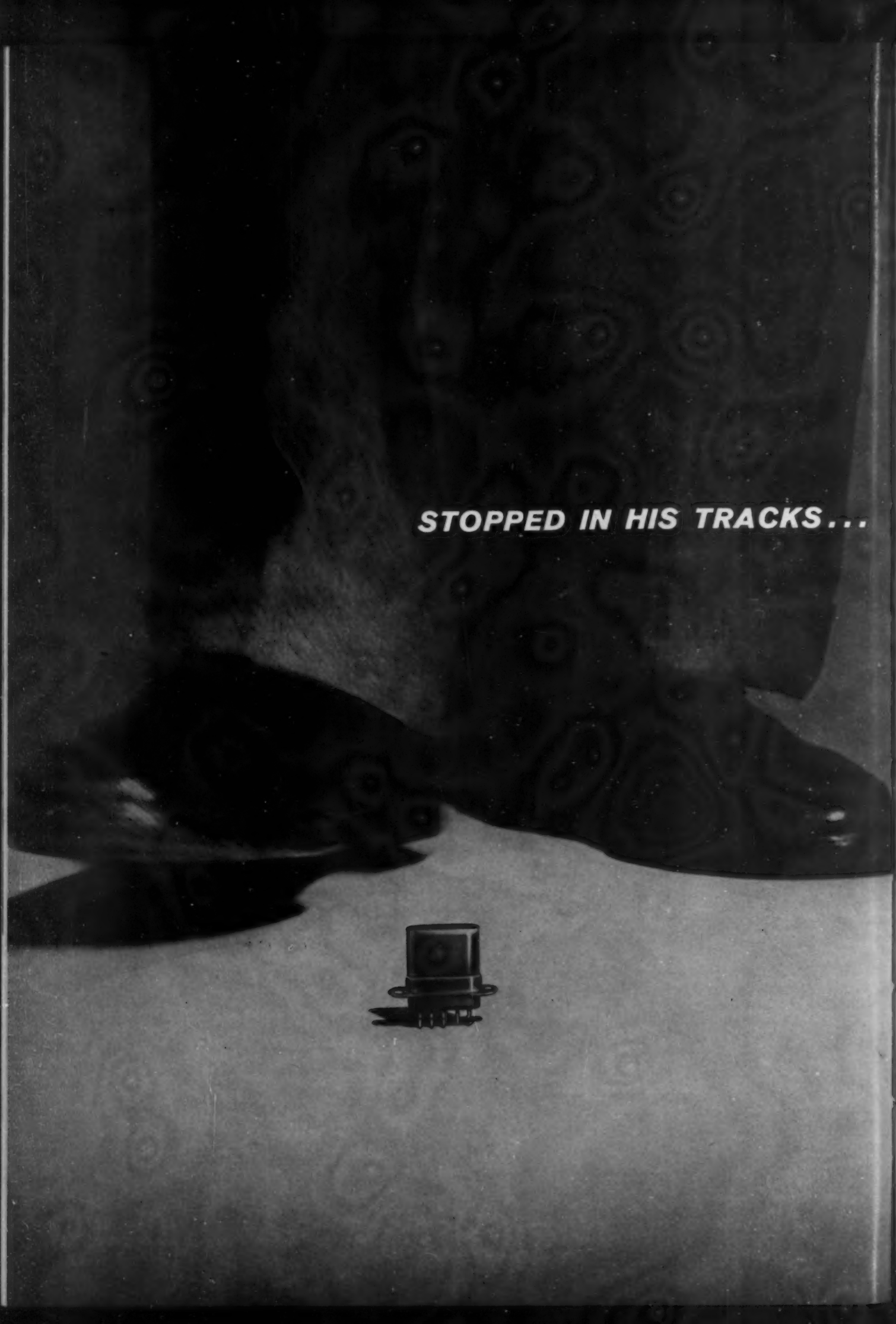
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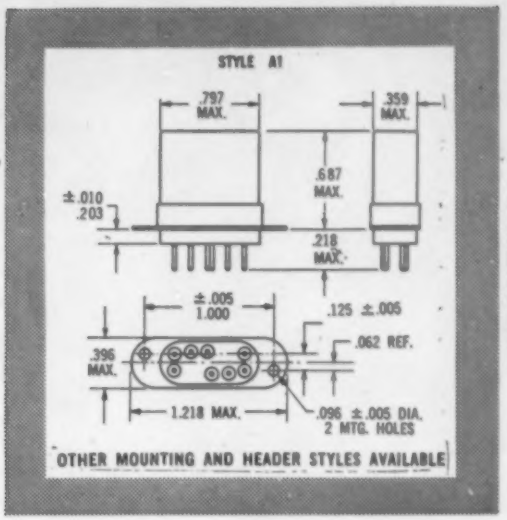

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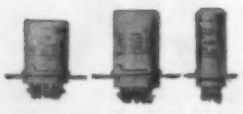

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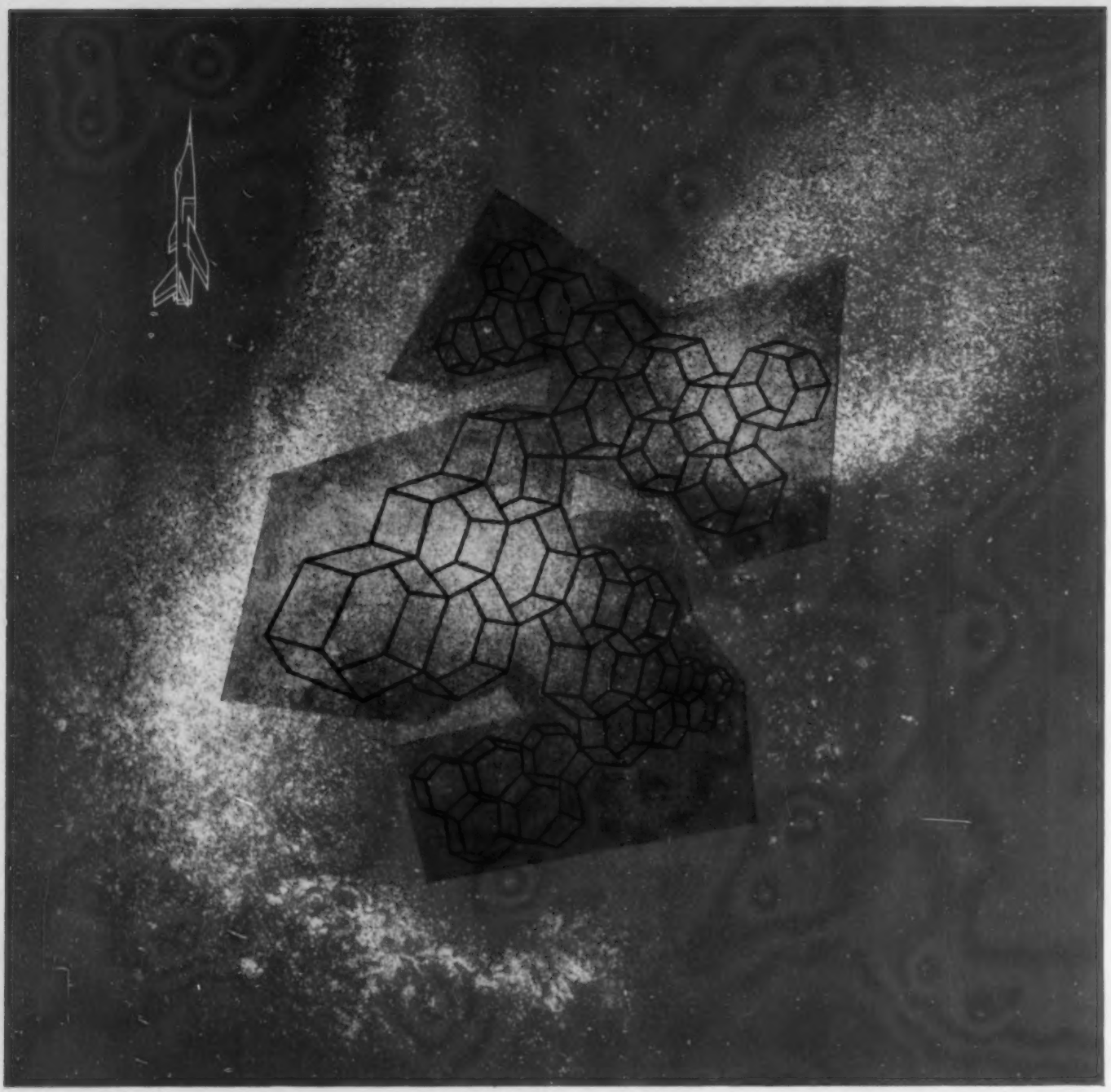

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Sweden Developing Atomic Missiles?

Jolt to U.S. and Red "atom-free" zone plans
Weapons technology greatly underestimated

By Erik Bergaust

OSLO, Norway—Krushchev's and Eisenhower's plans to establish an atom-free zone in Europe may not be so easy to put forward any longer. Reliable sources in Scandinavia have confirmed to m/r that Sweden is developing atomic warheads for its missiles.

Intensive research work is reported to have been carried out by the Swedish weapons concern Bofors in cooperation with that country's Federal Atomic Power Office and other concerns, such as Svenska Aeroplan A/B (SAAB). Norwegian sources say "it has been known in defense circles for some time that Swedish nuclear scientists made a breakthrough, strictly on their own, two years ago, leading to the development of atomic missile warheads."

As late as January 14, Krushchev warned Norway and Denmark that "Russia would take adequate countermeasures" if the two NATO countries allowed the United States to establish ballistic missile bases on their soil. The warning followed Soviet Premier Nikolai A. Bulganin's suggestion for an atom-free "de-missilized" zone across Scandinavia.

In an interview in the Kremlin with a correspondent of the Danish newspaper Dansk Folkstyre, the Soviet Party leader cautioned against acceptance of NATO "militarization" by either Norway or Denmark.

He included in this category the stationing of intermediate range ballistic missiles within their boundaries and creation of a proposed British-West German-Danish Baltic Sea Command.

"If the governments of Norway and Denmark accept nuclear and rocket weapons on their territories, the Soviet Union will, of course, be forced to take countermeasures," he said.

However, neither Russia nor the United States has approached Sweden in this respect, both of the big powers obviously overlooking Sweden's weapons capability and tremendous technological progress in recent years. The largest and most advanced of the three Scandinavian countries, Sweden is considered the third European power today (after Britain and France), and the Swedish Air Force and Navy are considered highly advanced.

Neutral Sweden has had no foreign help in developing its super-torpedoes, jet fighters, automatic electronic guns and missiles, yet it has been known for some time that this country's nuclear research has been carried out to the fullest extent.

Norwegian sources confirm that the main emphasis in Sweden's missile program is on SAMs and missiles for coastal defense. Work has been underway on other types for some time, but not with the high priority placed on aircraft-interceptor missiles in the *Bomarc* and *Nike* classes. Surface-to-surface missiles for naval use have been under study, but application of these to land operations has not been pushed.

Sweden's total missile industry activity includes many areas, but not IRBMs or ICBMs, and puts little dependence on foreign production. An exception to this, however, is the September purchase of ten *Jindiviks* from Australia. Another type drone is being produced by A. B. Flygmal Co.

Bofors has developed a guided AAM for use on the J35 interceptor. The Saab A32 *Lansen* all-weather attack aircraft is also equipped to handle Swedish-developed AGM for tactical strikes. One of these aircraft rockets is the *Jaktrobot* (fighter missile), the Type 304, which is due to become operational soon, as is the *Sjorobot* (sea missile) for naval surface-to-surface use. These weapons might be fitted with nuclear warheads.

The 304 is currently undergoing extensive trials prior to its introduction into service. It is already in limited production. The new missile was developed by the Swedish Guided Weapons Bureau in collaboration with other governmental and civil organizations. Its production is handled by the Air Force's own central workshops and civil subcontractors.

Very little technical information has been revealed on the 304 except that it is rocket-powered and is fitted with an all-weather guidance system.

The 304 is regarded as an extremely important weapon in Sweden's defense against an invasion over the sea. It will enable the *Lansen* units to fire with utmost precision against enemy naval vessels well outside the range of conventional antiaircraft artillery.

In addition to the Air Force 304 missile, a new naval surface-to-surface guided missile, known as the 315, has been designed for use from destroyer-type vessels against other vessels.

The new missile, now undergoing trials at sea, will initially equip the destroyers *Smaland* and *Halland*.

Acceleration to flight speed is provided by four built-in booster rockets. For cruising it uses a special type of jet engine, presumably an advanced type of pulse-jet engine. The missile has an all-weather guidance system. The greatest advantage of the new missile is that it permits firing at targets outside the range of conventional artillery. The missile is 26 feet long.

In general, Swedish guided missile development is handled by the Guided Weapons Bureau. The Swedish policy is to develop only such missiles that cannot be purchased abroad.

AC Spark Plug Shows New Guidance Plant

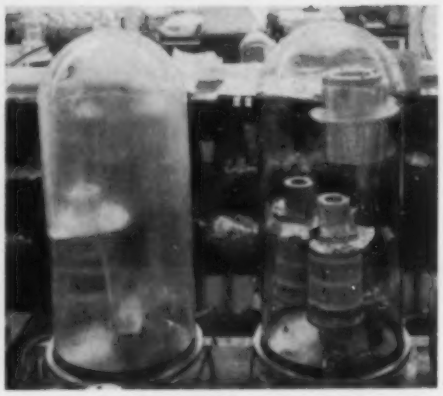
by Raymond M. Nolan

OAK CREEK, Wis.—AC Spark Plug division of General Motors recently opened the doors of its Oak Creek inertial guidance manufacturing facility to members of the press. In a day-long tour, newsmen were guided through all parts of the partially opened plant.

Manufacture of the *Thor* guidance systems (as well as systems for the *Regulus* and *Matador* missiles), now being carried on in AC's Milwaukee plant, is gradually being shifted to the 225,000 square feet of the new building now available for use. Further additions of 135,000 square feet in April 1958 and 140,000 square feet in October 1958 plus the 500,000 square feet in Milwaukee will give AC a total of 1 million square feet before year's end.

It was not disclosed by the company how much of this space would be used for *Thor* and how much would be used for *Regulus, Matador* and other defense operations carried out in the Milwaukee area. However, the apparent similarity of *Thor* guidance to that of *Regulus* and *Matador* probably effects some saving in time and money in setting up operations and allows simultaneous production without impeding any of the three programs.

Most impressive of the areas visited were the hygenically clean gyro assembly rooms. Women assemblers, sans makeup and garbed completely in nylon clothing, go through a 30-mile-per-hour blowdown chamber before entering the temperature- and humidity-controlled rooms. Precautions even extend to the use of lintless paper and ballpoint pens for necessary records. The liquid-floated gyros are completely assembled here and the high-density suspension fluid is placed in the gyro while it is at near-vacuum in a bell jar.



Gyros in bell jars being filled with fluid.

In an apparent effort to make the guidance systems more producible at the expense of miniaturization, vacuum tubes are used in place of transistors. Stabilized platform gimbaling has evidently been designed with rigidity rather than size and weight as the primary consideration. Weight of the system is classified but appears to be well over 500 pounds, although a minimum of miniaturization could cut this figure considerably.

It is interesting to note that the entire Oak Creek facility, as well as all tools except those which cannot be used for other than guidance system manufacture, is GM- rather than Government-financed. Mr. S. E. Skinner, GM vice president, who spoke at the open-house affair, stated that the corporation expected to continue research and development in order to improve existing products and that he would pledge full company resources behind these efforts.

According to Mr. J. A. Anderson, general manager of the AC Spark Plug division, 5400 people including 1400 engineers are now employed in the Milwaukee area and are supported by 300 engineers and other manufacturing personnel in Flint. Even though 1958 expansion plans will add 275,000 square feet, Mr. Anderson does not see a proportionate increase in the work force because of the GM policy of extensive subcontracting.

If GM can hit its goal of 50 per cent subcontracting when the programs are at full level, results should be beneficial to a good part of the electronics industry. At present, there are 3200 subcontractors participating, but Mr. Anderson did not indicate whether this total would increase with the size of the missile programs.

Dollar volume of the contracts in force at Milwaukee was not given, but a figure of $38 million for R&D and pilot production for *Thor* guidance has previously been published.

Mr. Anderson stated that guidance would cost in the vicinity of 25 per cent of the *Thor*. Basing a guesstimate on General Schriever's recent statement that production *Thors* would cost $750,000 per copy, it appears that AC is shooting for a cost of around $190,000 a system. Present labor force totals and estimated material costs point to a spending level this year of somewhere between $110 and $125 million for AC–Milwaukee (and Flint supporting operations) but production figures remain buried because of the intermingling of the three missile programs plus the other defense work AC is doing.

Final checkout of THOR guidance system in "raceway" simulating missile wiring.

Administration Budget Sets Minimum for Missiles

by Seabrook Hull

The important thing to remember is that the President's official budget request for fiscal year 1959 is the least Congress will approve. The consensus of Congress—most Democrats and some important Republicans—is that it is "too little, too late." It is virtually certain that more money will be authorized by Congress than the President has asked.

The budget shows a $1-billion increase in expenditures for 1959 (to $45.8 billion) for "major national security programs" over the fiscal 1958 total, yet economists point out that inflation will gobble up most, if not all, of this.

Some insist that it even means we will be buying less defense in 1959 than in 1958, and that we have bought less in 1958 than in 1957. In a word, in the view of many, it fails to recognize the Soviet threat.

It is almost as though the Administration wanted Congress to take the lead in setting the top limit of the post-*Sputnik* effort. This has political overtones. Congress is controlled by the Democrats; the Administration is Republican. If an "all-out" budget results in heavy deficit spending or a tax increase (now being talked on Capitol Hill), the Republicans in this fall's Congressional and 1960's Presidential elections can point the finger and say, "They did it."

In any case, it's Congress that will really set budget levels. It will also have a lot to say about how the effort is organized—reorganization of the Pentagon, establishment of a Department of Science and Technology (bills have already been introduced to do this), etc. Insofar as the budget is concerned, Congress now feels that it will take a minimum of $1 billion more than the President has asked, perhaps as much as $2 billion. But, what the Russians manage to get into outer space between now and this June 30th will have a lot to do with the final total. Any other technological accomplishments will also have an effect. The more Russia does, the higher the tote will go.

President Eisenhower, in his message to Congress January 13, asked for new obligational authority for the country as a whole totaling $72.5 billion, resulting in a total expenditure for fiscal 1959 of $73.9 billion.

For the Defense Department (including Army, Navy and Air Force) the President's $1.3-billion supplemental appropriation request for the current fiscal year raises the total obligational authority (pay, allowances, purchases, contracts) for military function to $36.6 billion. The equivalent 1959 total is $39.1 billion—up $2.5 billion from current 1958 figures.

Expenditures in 1958 are now estimated at $38.9 billion compared with an original estimate of $38 billion. The budget document says: "Estimated expenditures for 1959 are $39.8, an increase of $0.9 billion over the current estimate for 1958, $1.3 billion higher than in 1957, and $4 billion more than in 1956."

Of Defense Department expenditure totals, $5.3 billion are earmarked for U.S. missile programs—"for missile research, development and procurement, for guided missile ships and for missile-related construction." This total compares to $1.2 billion in 1955, $1.7 billion in 1956, $3 billion in 1957 and an estimated $4.3 billion this year.

Total for 1958 is fairly well fixed, due to the pure inertia of acceleration. However, Congressional action will probably add at least another $500 million into the 1959 figures.

Actual procurement of missiles (not including R&D, construction, missile ships, etc.), starting at $700 million in 1955 is listed at $2.9 billion for 1958 and $3.3 billion in 1959. In addition, on the order of $200 million is listed for procurement of missiles to be sent to Europe under the terms of the North Atlantic Treaty Organization. Potentially, these include *Corporals*, *Redstones*, *Sergeants*, *Jupiters* and *Thors*.

New obligational authority—which controls rate of contracting—is of the same order of magnitude to slightly higher—$3.8 billion for missile contracts in 1959. Expenditures set the money you'll actually take in during any given period. Obligations control your new business—volume of contracts you'll sign.

Still talking expenditures—actual cash outlays—the budget lists $13.9 billion for procurement of major equipment such as missiles, ships, planes, electronics systems, etc.; $2.3 billion for "major national security public works" (construction) and $2.3 billion for "major national security conduct of research and development." The three categories add up to $18.5 billion. Missile programs account for nearly one-third (28.6%). In fiscal 1958, the overall figure is $18.1 billion and the missile percentage, 23.7.

What this boils down to is confirmation that missiles, rockets and space flight have now come into their own. Within two to three years they will be the single most important market in the country. You can already see the increase in the rate of contracting. The lid that was on during the last six months of calendar year 1957 has been thrown away. Contracts are now being placed as fast as they can be negotiated and as fast as industry can absorb them. Meanwhile, the President would cut spending for aircraft and "other conventional" weapons by $1.5 billion.

The budget makes big noise over the fact that "about 90% of the dollars programed for missile procurement in 1959 are for weapons which were not in production in operational quantities in 1955." But nothing could be more normal—or expected. In any case, the budget goes on, "the longer range ballistic missile systems—*Atlas, Titan, Thor, Jupiter, Polaris*— . . . will account for just about half of the missile procurement program for 1959." This is a measure of the current emphasis.

Further indicators are supplied in the budget document: "*Jupiter* and *Thor* . . . are being placed in production. Work on the *Atlas* . . . will be accelerated. Funds are also provided to speed up the operational availability of the *Polaris* . . . and the first three submarines designed to employ this weapon." Since the budget was transmitted, another six *Polaris* subs have been requested.

"Expansion and further improvement of the continental defense early warning network will be undertaken and construction of a new ballistic missile detection system started. . . . [Accelerate] the dispersal of Strategic Air Command Aircraft to additional bases. . . . Funds are provided for an expanded research and development effort on military satellites and other outer space vehicles, and on anti-missile missile systems. . . . An increase is also included for basic and applied research in other areas."

Significantly, the President also says: "This means, among other things, that we must eliminate programs and facilities no longer needed and make sure that we have no needless duplica-

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tion. . . . The Department of Defense is now operating a very large number of installations. . . . Some of these installations involve use of costly or extensive facilities for activities that could be performed more economically at other locations." Presumably this would involve some switch of these activities from Government to private industry, particularly in the area of applied research and development where the Government has spent hundreds of millions of dollars in supplying industry with facilities since the end of World War II.

Taking official estimates of new obligation authority asked, the following breakdown, by service, results:

Army: Manpower's to be cut from 1,109,000 men in 1955 to 870,000 by June 30, 1959. All divisions will be reorganized along pentomic lines, which includes, among other things, "missilizing" with *Honest John*s, *Little John*s, *Lacrosse*s, *Dart*s and *Corporal*s —soon to be replaced by *Sergeant*s. The budget notes that the Army has organized four missile commands since 1955 and will have "a considerably larger number of separate surface-to-surface missile battalions" by June 30, 1959—*Redstone*s and *Sergeant*s.

While the budget at no point gives any idea of procurement in terms of actual numbers of missiles, it's possible to give some indication of the volume of purchases. *Honest John*s, *Little John*s, *Lacrosse*s and *Dart*s in numbers probably will run (including those already on order) in the lower to middle tens of thousands each. The *Corporal-Sergeant* category will total in the thousands. *Redstone*s, it is expected, will be in the high hundreds, including those to be supplied to Europe.

Army's antiaircraft battalions will be cut from 122 to 86, but the number of missile (*Nike-Ajax* and *Nike-Hercules*) battalions will "more than double (over 1955)" to 73 in 1959 compared to 65 in 1958, with the reduction coming in 90- and 120-mm AAA gun battalions. Only one of these is to be left in the Army by June 30, 1959. No mention was made of giving the Army authorization to use the *Jupiter*. However, since the budget came out, Army has been given the go-ahead to produce a solid-propellant missile (named *Pershing*) to replace the *Redstone*, having a range on the order of 500 to 700 miles.

For procurement of "ammunition and missiles" the Army has programed $758.2 million for 1959, compared to $865.8 million in 1958 and $745.7 million in 1957. While the net increase is not very great, the shift of emphasis within the total is heavily in favor of missiles, though no official breakdown is available. In research and development, Army has programed $145.4 million for 1959 for "guided missiles and related equipment," compared to $128 million estimated for 1958 and $113.1 million in 1957. Other missile R&D funds are also included in the categories "artillery and other weapons and related equipment" and "ammunition and related equipment." These two categories total $48.5 million, with again no breakout of missile and rocket funds. None of these funds in the separate service breakdowns include "pay and allowances" for military personnel or civilians working for the Government. The bulk will be available for contracting out to private agencies such as industry, universities.

Navy: For "missiles, drones and related equipment" Navy Bureau of Aeronautics lists $270 million in obligational authority planned for 1959, up from $264.6 million in 1958 and $203.3 million in 1957. For "ground electronic and detection equipment" the totals are $37 million, $32.3 million and $26.3 million respectively.

According to the budget document, Navy's $1,159 million 1959 shipbuilding program includes "15 guided missile ships [surface] one of which is to be nuclear powered."

Bureau of Ordnance lists $371.9 million for procurement of guided missiles, including "sizable increases . . . for evaluation, improvement, and production of both defensive- and offensive-type missiles, especially for *Polaris*." Totals for this category in 1957 and 1958 were $159.7 million and $188.5 million respectively. Ordnance also lists a $103.5-million category (down from 1958) called "ammunition" which includes "adaptations for nuclear warheads . . ."

In research and development, Navy shows a $274.3-million total for "guided missiles and related equipment" in 1959, compared to $187.6 million and $159.3 million in 1958 and 1957 respectively. Other missile, rocket and missile-related electronics R&D funds are also included in the combined total for "ammunition" and "other equipment" of $80.2 million. The Navy's fiscal 1959 R&D budget is heavily weighted in favor of "augmented effort in the development of surface-to-surface missiles."

Air Force has programed procurement of missiles in 1959 at $1,728 million, up from roughly $1.5 billion for each of the two years 1957 and 1958. This compares to aircraft procurement of $4.9 billion scheduled for 1959 and $5.9 billion for 1958, a drop of $1 billion.

The continued emphasis of the Air

Force budget on manned aircraft, particularly SAC bombers, means strong Air Force emphasis on "standoff" air-to-surface missiles such as *Rascal*, and "decoy" countermeasure missiles such as *Goose*. However, biggest single missile category listed in AF budget, of course, is the big ballistic missiles—*Titan, Atlas, Thor* and *Jupiter*.

Other AF categories where missile and missile-related funds are found, but for which no breakout of actual missile money is available, include (all 1959 figures): weapons, ammunition and propellants (includes aircraft rockets), $95.4 million; ground communication-electronic equipment (ballistic missile detection), $705.7 million; ground handling equipment (launching, guidance and ground test equipment), $873.5 million. Budget states that this latter figure will increase still more in later years. The 1958 total is programed at $444.7 million.

AF research and development for "guided missiles and related equipment" totals $94 million for 1959—up from $64.2 million and $83.3 million in 1958 and 1957 respectively. The AF's biggest research and development total, however, is listed under "operations and management" and totals $332.9 million for 1959 compared to $322.9 million in 1958 and $308.9 million in 1957. These sums provide for "operation, management and maintenance of the research, development and test facilities of the Air Force such as the Air Force Missile Test Center."

By and large these three Army, Navy and Air Force breakdowns show all the missile obligational authority available for contracting in fiscal 1959. Parallel breakdowns of funds actually to be expended are not tabulated in the budget book. This is probably due to imponderables as to individual projects—just how rapidly various missiles can be brought to the production stage, for example. However, expenditures will lag obligations, traditionally approximating contracting volume of 18 months earlier. Congress could speed up spending.

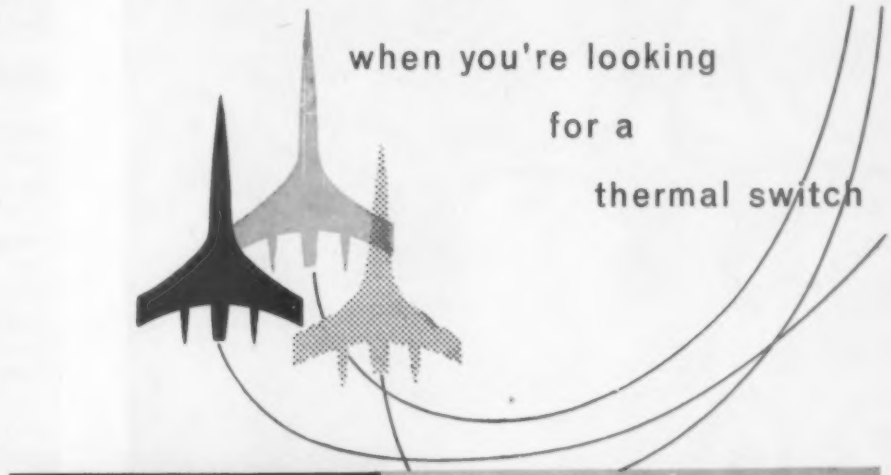
Total scheduled expenditures in research and development for "major national security" for fiscal 1959 are listed as $3.1 billion, including $2.9 billion for the conduct of research and development and $243 million for new plant. These compare with 1958 figures of $2.6 billion, $2.3 billion and $270 million respectively.

Additional R&D budget items of missile and astronautics interest include: a $140-million expenditure for the National Science Foundation—over three times the current 1958 total; National Advisory Committee for Aeronautics, $100.5 million—up from $94 million this year; National Bureau of Standards, $9.8 million—up from $7.8 million in 1958.

Any new obligational authority added by Congress will measurably increase contracting authority from June 30 on. It will increase actual expenditures somewhat during fiscal 1959, but will have its greatest impact in the year following.

As yet Congress has not specified its proposed increases. The total figure talked is $2 billion. It would be used to hike planned purchases of SAC bombers, support of long-range (space flight) projects and strenthening of "conventional" forces. Included in this may well be airlift capabilities for missiles.

And, after it's all done and Congress has gone home for the summer and the 1959 appropriation is settled along with the dust, it still isn't going to be certain how the money will be spent. The White House has assumed in the past, and may do so again, the privilege (through the Budget Bureau) of spending or bottling up funds pretty much as it wishes.



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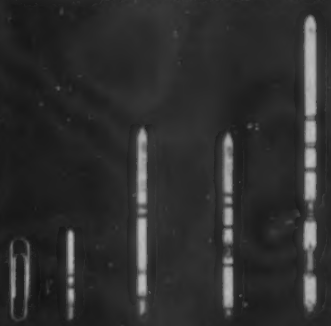

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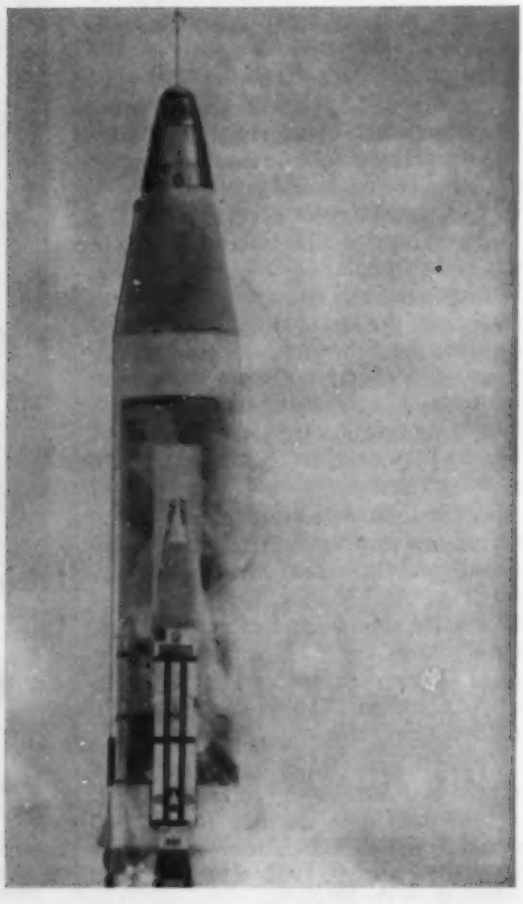
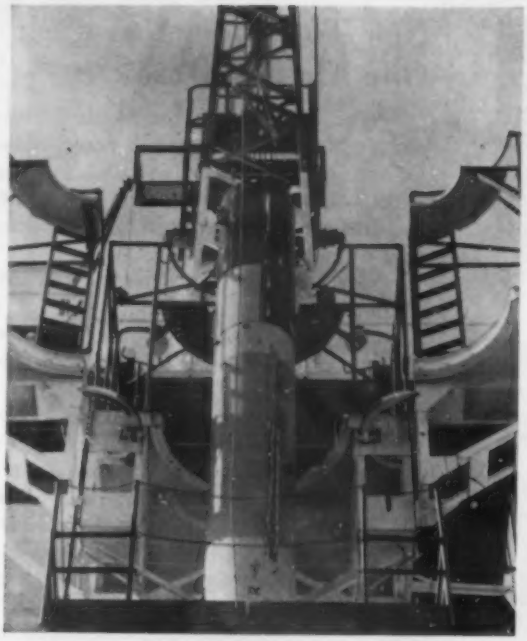
U.S. MISSILES in the NEWS

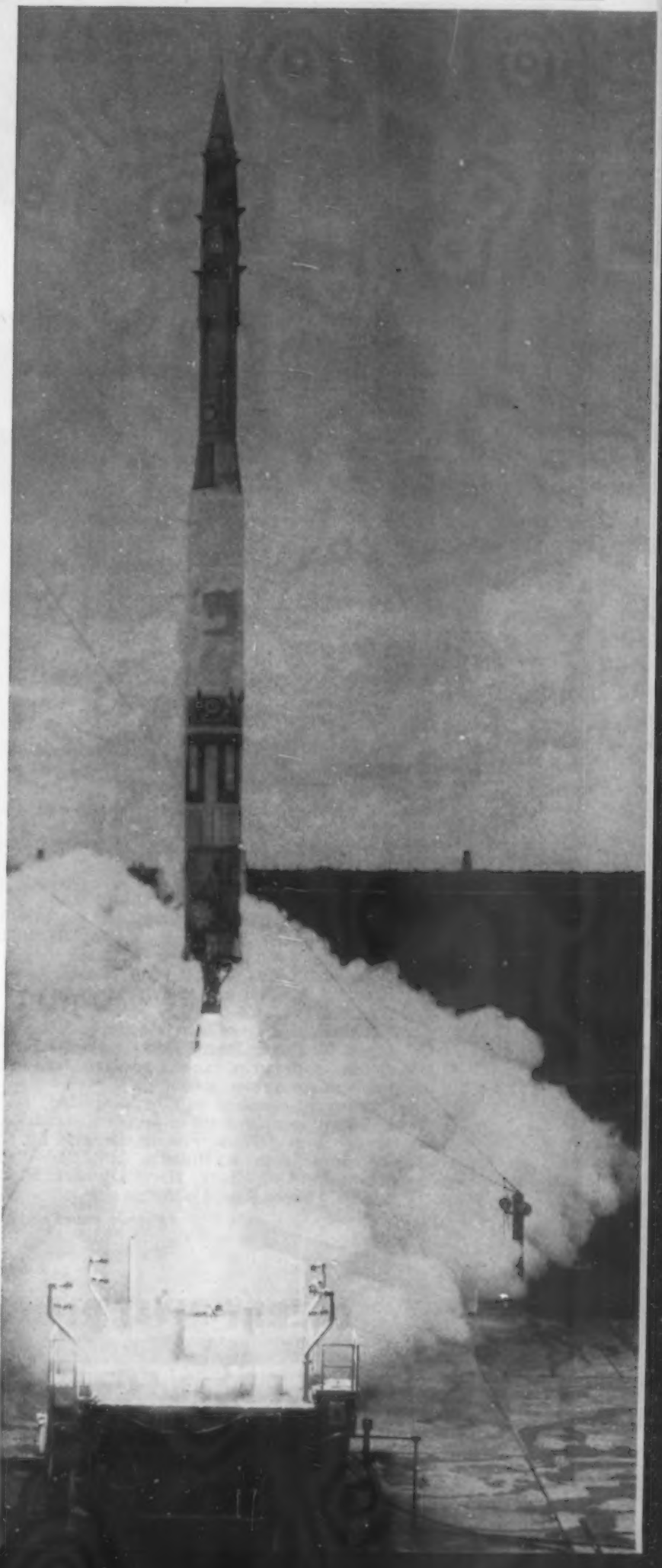
AFTER TWO unsuccessful flights last June and September, the Convair *Atlas*, in two limited demonstrations, has finally proved the reliability and feasibility of the missile's boost and vernier rocket engine system.

The first successful flight was an evaluation of the missile's two 165,000-pound-thrust boost engines. Last flight was a four-rocket test—booster engines plus the two small vernier rockets used for fine adjustment in controlling pitch, yaw and roll.

The most complex phase of the testing program is still to be attempted. This will be the "complete engine" test where all three propulsion engines must operate in unison. When a sufficient velocity is reached, the two booster engines will drop away and the sustainer engine will accelerate the missile to "full-range velocity." This marriage and divorce of the propulsion system may require several tests before reliability is achieved.







THE LAST week of January was one of hectic activity and waiting overlaid with apprehension and frustration for the people of the *Vanguard* program. TV-4—fourth in the series of *Vanguard* test vehicles—in the second attempt to place a "grapefruit" satellite in an orbit, had been sitting on its launching pad since January 15.

Although project officials had wrapped the tightest security blanket around the launching attempt to prevent a recurrence of the publicity-induced strain on the crew, tension was high. This time it was the weather and mechanical difficulties that postponed the firing from day to day.

Greater than the previous spotlight pressure, however, was the strain from the schedule stretchout. For while the complex, untried, on-again, off-again *Vanguard* was taking its own time, its well-proved competitor, the *Jupiter-C*, was erect on a nearby launching pad, scheduled to be fired January 29 (pp. 112-113).

Double proof of proper installation—even on completely blind applications—is now possible with Cherry rivets. Two visual check points are now available to the inspector.

Grip length on new Cherry 600-700-800* series rivets is clearly stamped on the head of each rivet stem. Even after installation this provides ready inspection of the rivet grip length used.

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This double proof is in addition to other advantages, for these Cherry rivets also provide strong clinch, wide grip range, positive hole fill and uniform stem retention.

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*Patents issued and pending

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New Torpedoes Unveiled; One Already Obsolete

The U.S. Navy's recent announcement giving details on two new acoustic-homing torpedoes in use by the Fleet was followed 48 hours later with the statement that one of the weapons was already obsolete.

The units described were the *Mark* 32 and the *Mark* 43, first types of a new series developed by the Navy in its stepped-up concentration on antisubmarine warfare.

The *Mark* 32, one of the simplest torpedoes ever developed, is carried on the deck of its launching ship and fired by tossing overboard. When it hits the water, the acoustic homing devices are activated and guide it to target. General Electric and Philco share credit for development. It is produced by Philco and the Naval Ordnance Plant in Forest Park, Ill.

The *Mark* 43 differs from the *Mark* 32 in that it can also be launched from an airplane. Dimensions were given as eight feet long and ten inches in diameter, and the weight as one-eighth that of aerial torpedoes used in World War II. Power comes from a self-contained battery.

Rear Adm. E. E. Withington, Chief of the Bureau of Ordnance, said the *Mark* 43 was "actually a submersible guided missile capable of searching to great depths for enemy targets."

Two days after the original release, the Navy disclosed that it was working on a replacement for the *Mark* 32 at the Forest Park ordnance plant. No details of the new development were given, but the Navy said that production of the *Mark* 32 ended in 1955 after a sufficient number for training and combat use had been manufactured.

Fred Morris Organizes Electronic Consultant Firm

The Electronic Engineering and Management Consultant organization has established offices in Palo Alto, Calif., under direction of Fred W. Morris, Jr. The office will serve principally an unidentified eastern organization in planning the establishment of a West Coast affiliate.

Morris, a graduate of the California Institute of Technology, has completed graduate study at Stanford University and Occidental College. His technical specialties include advanced military electronic countermeasures systems, counter-countermeasures, reconnaissance and radar systems, and electronic weapon system performance.

Morris and his associates have been active in engineering and management consulting since World War II.

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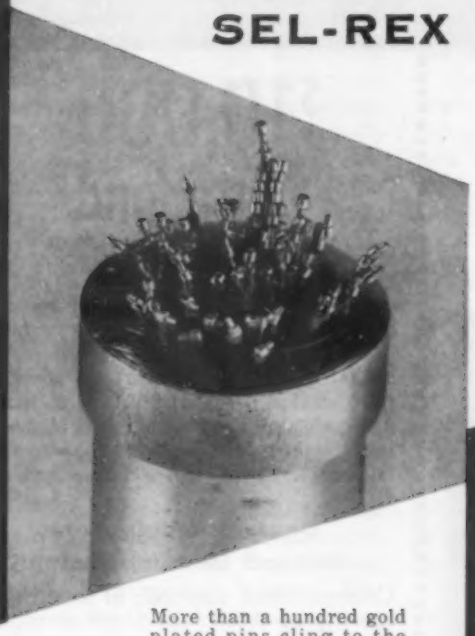
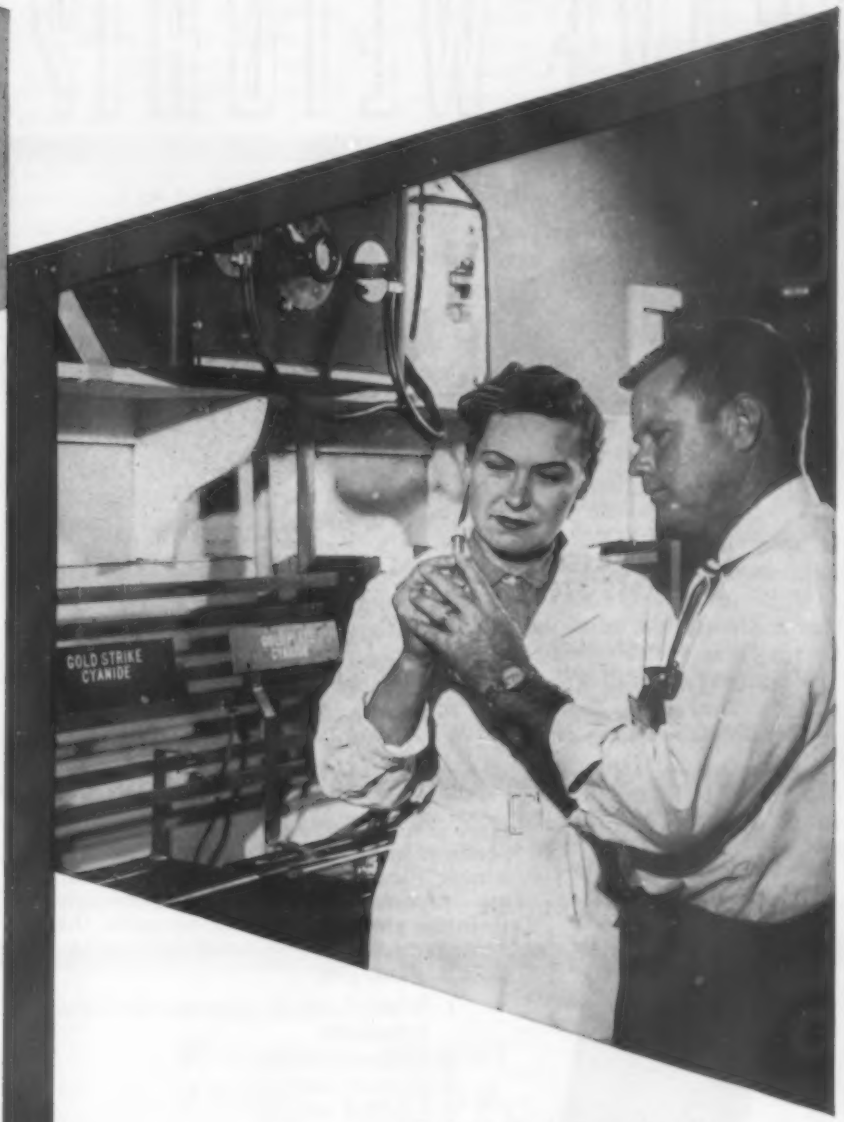


More than a hundred gold plated pins cling to the magnet. Magnification approximately ten times.



Technicians inspect the miniature pins which had to be processed on a magnet to prevent loss during the plating operation.

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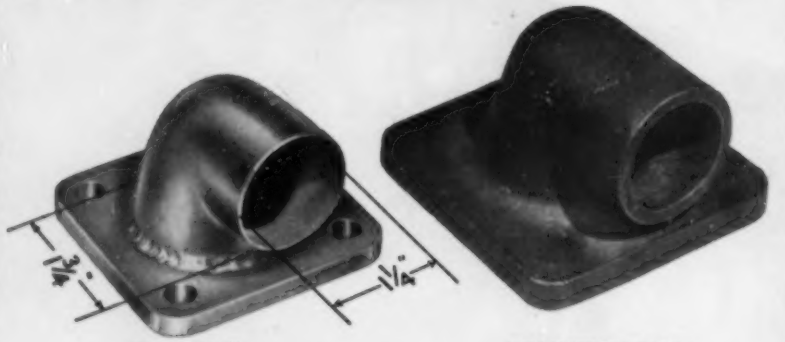

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Army to Replace *Redstone* With *Pershing* Missile

by Norman L. Baker

The Army has been authorized to proceed immediately on a top-priority development of a solid-propellant ballistic missile that will eventually replace the *Redstone*. Work on the new missile, named the *Pershing* (after Gen. John J. Pershing, the famed Army commander of World War I), has already moved into high gear.

Pershing will be smaller, and more mobile than the present 200-mile *Redstone* liquid-fueled missile. This is the Defense Department's first move in a long-range program that plans to eventually replace all liquid-propellant ballistic missiles with solid-fueled versions.

Polaris, the Navy's fleet ballistic missile, is an example of the advanced "state of the art" in the development of large solid-propellant missiles. Defense Secretary Neil H. McElroy announced the *Pershing* authorization a few days before the Navy reported a successful launching of a *Polaris* test vehicle.

The House Military Appropriations Subcommittee approved the transfer from the Military Personnel account for R&D and procurement of $40 million for initial financing of the follow-on solid-propellant missile. Part of the funds are for the *Lacross*, *Little John*, and *Sergeant* second-generation development. Earlier exclusion of the Army from supplemental funds prompted the committee to reevaluate the Army's missile program.

The Army's *Sergeant* and the Navy's *Polaris* have pioneered the development of solid propellant missiles in the United States. The *Sergeant* program pioneered the development of large high-thrust solid motors which, with minor modifications, have been utilized for the propulsion system of the *Polaris* test vehicles.

Most of the basic research in the large solid-propellant missile field has been conducted by Jet Propulsion Lab. Manufacturing of the solid fuel for these missiles has been handled exclusively by Thiokol Chemical Co. Thiokol produced the first propulsion units for the *Polaris* test vehicles while Aerojet-General was preparing for the production of the development units.

The major breakthroughs in solid propellants have been realized in the last four years. The most outstanding has been the achievement of thrust and directional control. The range of the *Pershing* will dictate the use of the thrust control system. It will be possible to vary the *Pershing*'s range by presetting the controls before flight. This would be similar to a reduction of propellants in a liquid-fueled missile.

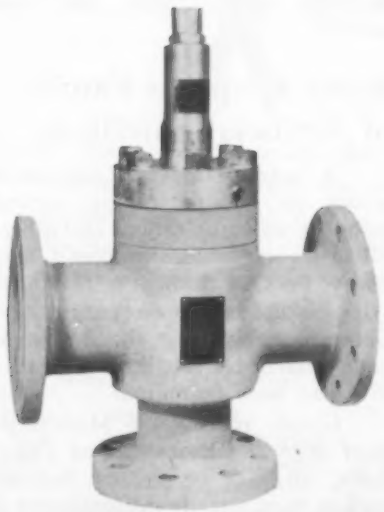
The theoretical maximum of specific impulse is rapidly being reached in the solid-propellant field. The addition of boron compounds to the solid fuel is upping the impulse figure to a very promising level. The disintegration of solid grains produced by varying temperatures is a problem of the past, so that it is possible to store the missiles for indefinite periods.

Russia has two solid-propellant missiles in the *Pershing* range category. The *Comet* III is an air-to-surface missile now in the operational class. A submarine-launched version, the *Comet* II has been in the Soviet operational arsenal for at least a year. Russia's history in the solid field dates back to World War II. At the present time the Soviet missile stockpile has several short-range solid-propellant rockets.

Army officials did not disclose when the *Pershing* was expected to be an operation weapon. The rapid progress in the *Polaris* program indicates that 1960 would be a conservative estimate. Thiokol Chemical is expected to get a slice of the development program as a result of their experience with the *Sergeant* and *Polaris* programs.

At almost the same time as the *Pershing* authorization announcement, Lt. Gen. James Gavin, the chief of the Army's R&D told Senate investigators the Army had received the go-ahead on a 500-mile midrange missile. The missile will be a modified *Redstone* with a lighter warhead.

Gavin testified that the Army had been repeatedly hampered in attempts to proceed with the program to develop the midrange missile. He stated



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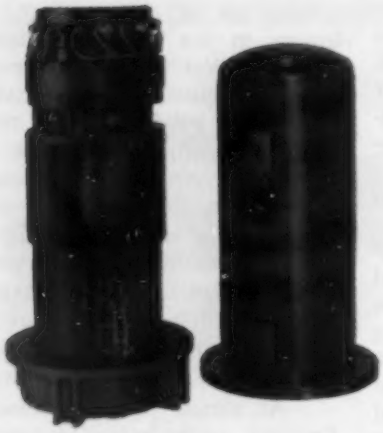

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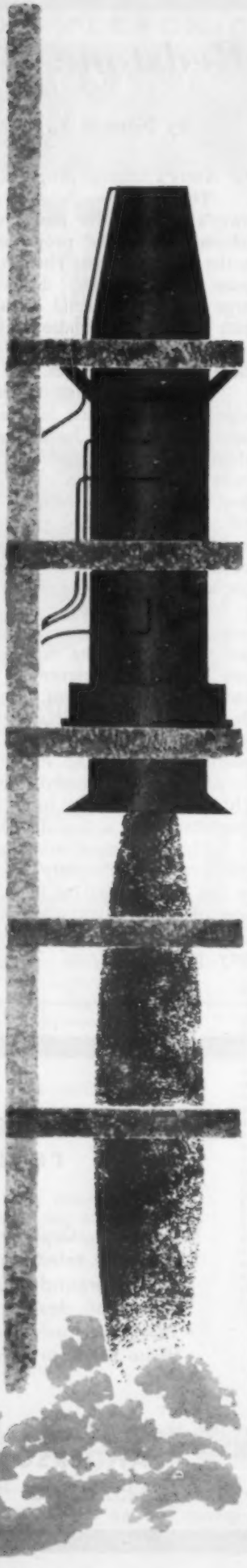

that two years ago the Army was directed to develop the missile, then ordered to forget the program and switch to the development of the 1500-mile *Jupiter* IRBM. In November 1956, Defense Secretary Wilson's roles-and-missions directive pushed the Army's allowable missile range back to 200 miles.

Gen. Gavin pointed out that the largest missile in the Soviet Army parade through Red Square last November 7th, the T-1, was the same kind of missile the United States could have been developing since July 10, 1955, when the Army first submitted the 500-mile missile program to the Defense Department.

The decision to allow the Army to develop the 500-mile missile is the first official deviation from the Wilson directive. Army operational control of the *Jupiter* IRBM may be next. Sen. Stuart Symington (D-Mo.) said he did not agree with the decision to hand the authority for operation of the IRBM exclusively to the Air Force. Sen. Estes Kefauver (D-Tenn.) said he doubted the wisdom of the plans to turn the operational control of the *Jupiter* over to the Air Force.

Launcher Protection Need Stressed by General

The future of NATO may be based on the mobility and protection of its rocket launching sites Maj. Gen. Brooke E. Allen, commander of the Sixth Allied Tactical Air Force, said recently.

Gen. Allen, in a speech before the Overseas Press Association in Athens, Greece said the degree of difficulty in hitting our launching sites parallels the enemy's danger in starting aggression.

Survival in today's rocket and nuclear-oriented world demands speed, flexibility and mobility, the general said.

Army Proposes Family of Artificial Satellites

A "whole family" of satellites that would be invaluable for surveying, mapping, communications and other applications has been proposed by the Army. Lt. Gen. James M. Gavin, testifying before the House Armed Services Committee, also said the Army might have launched a satellite two years ago if it had been permitted.

Gavin, retiring on March 31 as chief of Army Research and Development, told the committee that Army rockets have already demonstrated their ability to enter outer space and stated that the Army is convinced that its mis-

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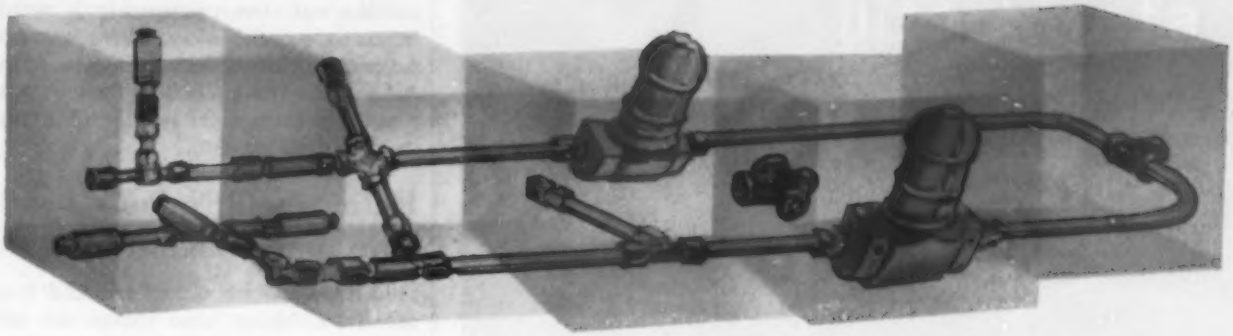

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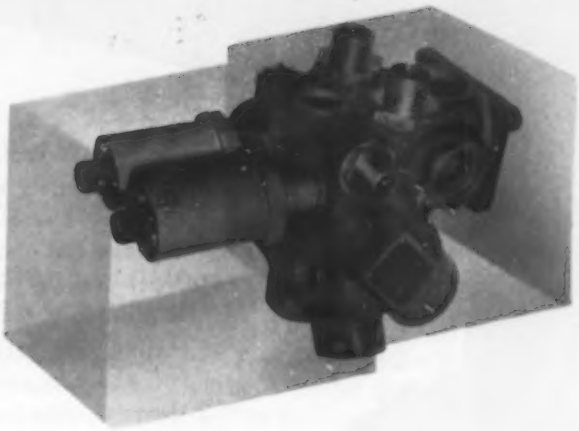

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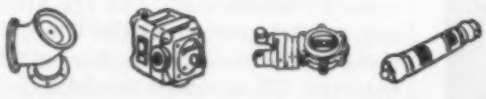

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sion can best be carried out by use of a family of satellites. He pleaded for full support of the proposal which is now undergoing study at the Pentagon.

There was no hint as to when the launching of such satellites would be carried out, but presumably it would be many months away. There was also no mention of where, if anywhere, the Air Force's WS-117L *Pied Piper* project fitted into the role of helping the Army carry out its mission.

Halmos and Nolan Join m/r Staff

Eugene E. Halmos, Jr., and Raymond M. Nolan have joined the m/r staff as managing editor and electronics editor, respectively. Halmos for the past 16 years has been managing editor and senior editor of ENGINEERING NEWS-RECORD magazine, a McGraw-Hill publication. He will join m/r on February 17 and serve under Erik Bergaust, executive editor.

Mr. Halmos was a newspaperman before joining ENR in 1941 as managing editor. Eight years later, he became senior editor. In 1957 ENR was the fifth largest business paper in the country in terms of advertising linage. During World War II he was a navigator in a B-24 group of the 8th Air Force based in England and spent several years in a German prison camp after being shot down over enemy territory.

Mr. Nolan, who joins m/r as electronics and guidance editor, comes from Ford Instrument Co. Division of Sperry Rand Corp., where he was assigned to the Missile Development Division. Before joining Ford, he was a technical writer for the Air Force, and served as a member of the technical advisory group to the Imperial Iranian Air Force for two years.

Henry P. Steier continues as electronics contributing editor of m/r.

Mystery Shrouds Thiokol Merger Possibilities

Thiokol Chemical Corp., one of the nation's largest solid-propellant rocket manufacturers, is increasingly the subject of merger rumors. First reports, some months old, concerned negotiations—a possible stock transfer—between Thiokol and Diversey Engineering Co. This apparently fell through.

More recently, rumors circulating financial circles have had (1) Thiokol buying Atlantic Research Corp.; (2) General Dynamics Corp. buying Thiokol; and (3) a tie-up (undefined) between Thiokol and Thompson Products, Inc.

Efforts to confirm or quash these

rumors by contacting the principals have failed. The continued reports, however, are significant. Thiokol is known to be desirous of close association with a hardware source. In addition, Thiokol has long had an interest in attaining a prime systems capability. For example, Dr. Hal Ritchey, Thiokol technical director, has developed a number of satellite and moon-rocket projects utilizing on-the-shelf solid-propellant rockets.

House Group Reports Out Missile "Gap" Money Bill

With dissatisfaction expressed over the inadequacy of the amount, the House Appropriations Committee favorably reported the President's $1.3-billion supplemental appropriation request for fiscal 1958. Next step, almost automatic in this case, is approval by the House.

The committee filled in what it considered to be some "gaps," mainly involving the Army missile effort. The supplement as approved by the committee would provide for $40 million to start the *Redstone* follow-on solid-propellant missile, not recommended in the President's message. The report also recommends that a portion of the Defense Department's $100-million emergency fund be used to accelerate the *Nike-Zeus* anti-missile missile program. It also called for a *Titan* speedup from the same source.

The subcommittee observed that the money "is an advance installment on the fiscal year 1959 program . . ."

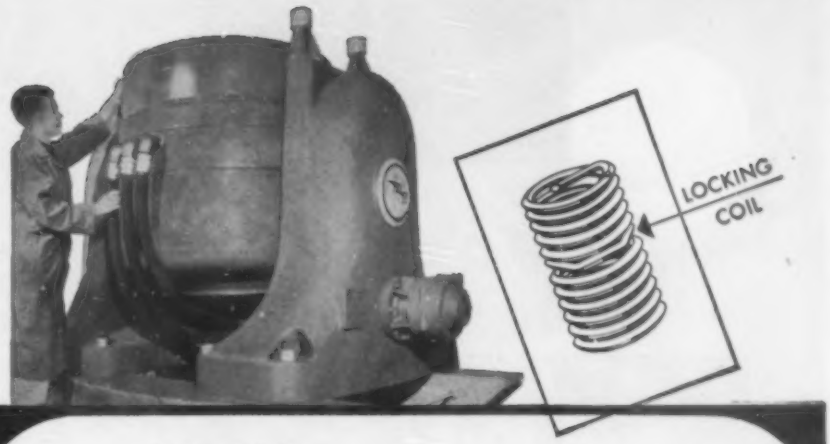
Chairman George Mahon (D-Tex.) commented: "The estimates on which the bill is based were lifted out of the 1959 budget. Except for it, the defense dollar budget for 1959 would be just that much higher."

In approving the supplemental request, the committee provided this breakdown of general spending categories:

	(millions)
SAC dispersal and alert	$218.6
Ballistic missile detection	329
Acceleration of *Atlas, Thor* and *Jupiter*	333.4
Acceleration of the *Polaris* and missile submarine program	350
Construction of extra SAGE communication center	29

The committee also authorized the Secretary of Defense to transfer $118 million to the still nonexistent Advanced Research Projects Agency.

The committee report reflected the liberal new attitude toward military spending that has developed on Capitol Hill since *Sputnik*. At one point the Presidential request was called "mini-



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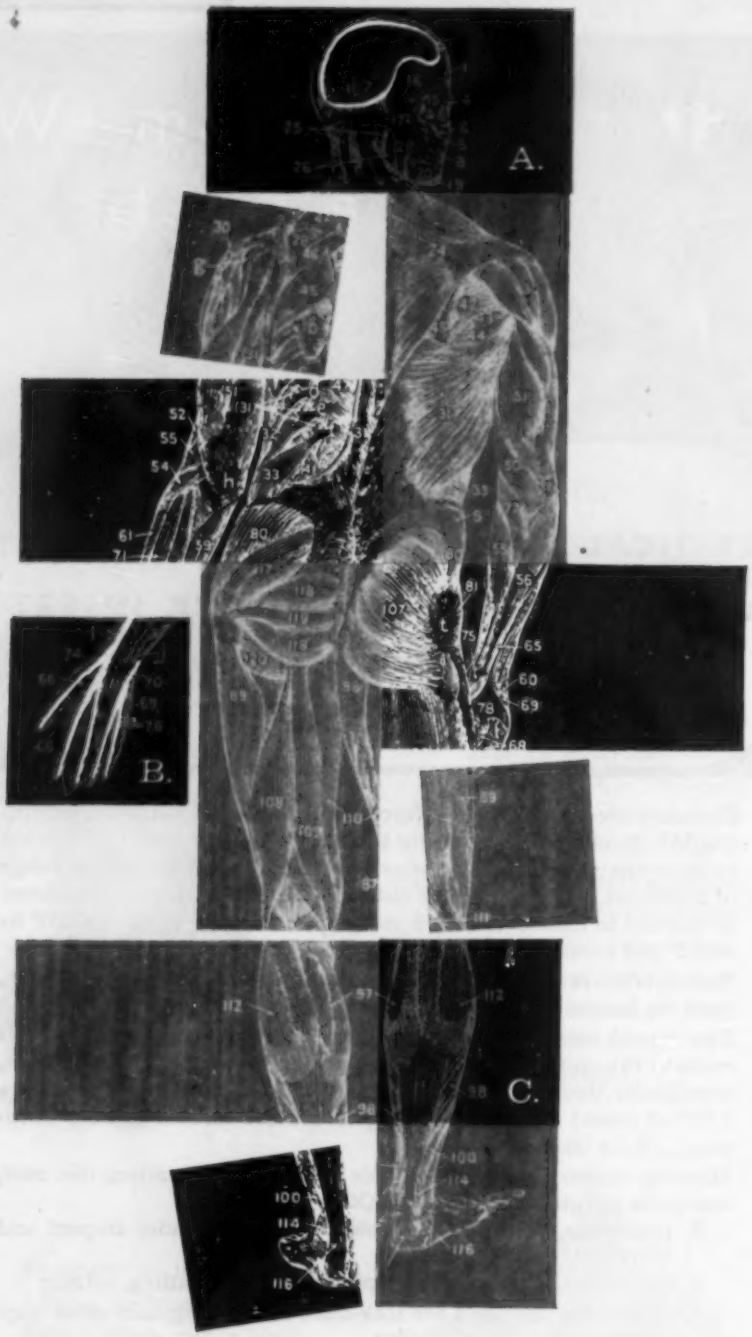

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mal" and the impression was given that the appropriations unit is expecting still other supplemental requests. The committee declared that the Administration's exclusion of the Army from supplemental funds prompted the subcommittee to take a closer look at the Army's missile programs. An order of Army priority stressed the need for funds to finance (1) the *Redstone* follow-on solid-propellant missile, the *Pershing*; (2) *Nike-Zeus* anti-missile missile; and (3) "second generation" divisional and corps-type missiles.

The Army said it would need $11 million for acceleration of the *Nike-Zeus*. The committee said this should be furnished from the emergency fund. Authorized for transfer from the military personnel account for R&D and procurement was $40 million for the *Redstone* successor and for *Lacrosse*, *Little John* and *Sergeant* second-generation work.

For the Navy, the subcommittee allotted $350 million for the *Polaris* missile and submarine program. Testimony confirmed that the Navy is advancing on the *Polaris* as fast as the "state of the art" will allow.

Air Force "procurement other than aircraft" was increased by $360 million, bringing the amount available in FY 1958 in this account to $1,531.5 million. Funds are projected this way: $20 million, acceleration of *Atlas* ICBM operational capability; $171 million, acceleration of *Thor* and *Jupiter* operational capability; and $169 million, acceleration of ballistic missile defense capability.

Quantum Rockets Available by 2000?

In forty years man will be using quantum rockets "moving with the speed of light," according to a Russian scientist. Prof. G. I. Babat made the prediction in answer to a question by the editors of the Moscow magazine ZNANIE-SILA.

In the same article Engineer V. Zheltenkov forecast a new kind of fuel for rocket planes which would be "obtained from air" by 1998.

Grand Central Rocket, Tennessee Gas Merge

C. E. Bartley, president of the Grand Central Rocket Co. of Redlands, Calif., has announced that the Tennessee Gas Transmission Co., Houston, Tex., has signed a letter of intent to acquire an interest in Grand Central and that final negotiations are nearing completion.

Grand Central, originally a division of the Grand Central Aircraft Co.,

Glendale, Calif., was organized as a separate company in 1954. In addition to classified projects, they participate in such missile programs as the Army's *Dart*, AF's HTV (hypersonic test vehicle), the *Vanguard* third-stage engine, and the third and fourth stages of Project *Far Side*'s vehicle.

Tennessee Gas is the country's largest transporter of natural gas, operating a system with more than 9000 miles of pipeline. They are also in the oil-producing and synthetic rubber business.

Mr. Bartley said that primary reason for consolidation was that further expansion calls for very substantial financial investments. He said the contemplated programs were classified but that they would be carried out in the Redlands area.

"Patently," he added, "there will be increased employment and a greater payroll as we get into these programs."

Jupiter On Schedule Chrysler Claims

In reply to rumors that Chrysler Corp.'s decision to fabricate as well as assemble the ballistic shell of the *Jupiter* was delaying delivery of both *Thor* and *Jupiter*, a Chrysler spokesman told m/r that the firm is fabricating *Jupiter* to assure that production schedules would be met. He also said that *Jupiter* production is on schedule.

Rumors circulating Washington claim that because the Chrysler decision would hold up *Jupiter* production, *Thor* deliveries would be held up to match *Jupiter* one for one.

In the case of the *Redstone*, Reynolds Metals Co. is the fabricator; Chrysler, the assembler. For a while it had been assumed that the same procedure would be used for *Jupiter*.

Meanwhile, Chrysler also reports that it is not going to build a large production plant at Huntsville, Ala., as previously suggested.

West Germany and France Sign Missile Pact

A formal agreement has been signed between West Germany and France concerning the operation of the joint French-German institute for the development of guided weapons. This institute has been located for several years at St. Louis in Alsace. In 1956 Germany contributed 9 million marks to the institute and a further 4.5 million in the 1957 budget. The scientific direction of the institute is in the hands of Professor Schardin, a German ballistics expert who was active in the Volkenrode establishment in Germany.

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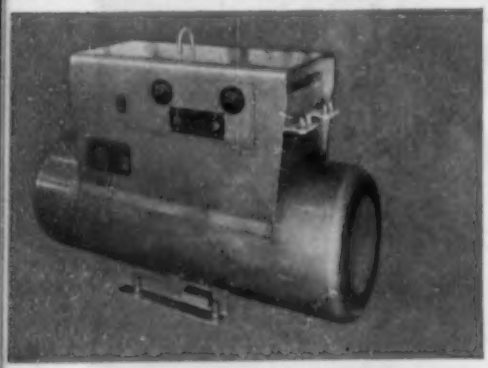

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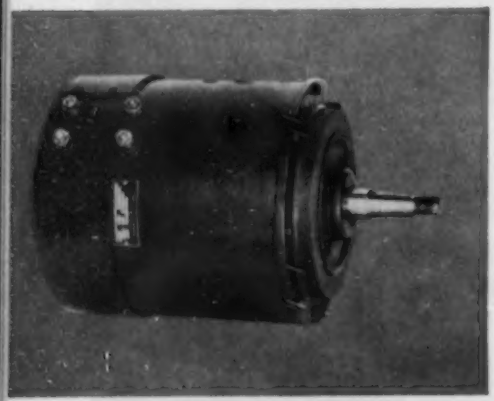

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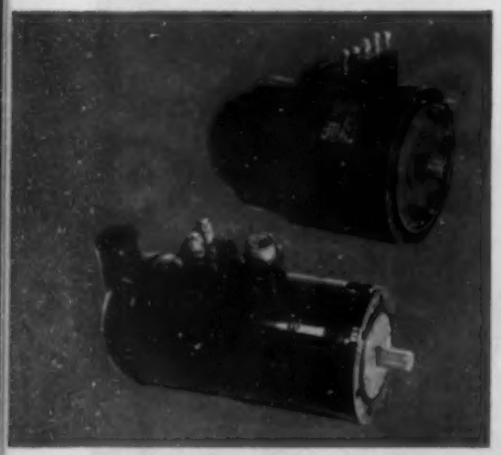

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Kapustin Yar Serves as Russia's Cape Canaveral

by Frank G. McGuire

Russia's major launching complex at Kapustin Yar, near Stalingrad, has been pinpointed by U.S. radar from several sites along the Soviet Union's southern border. The base, which has the functions and facilities of Cape Canaveral but the physical characteristics of White Sands, N.M., is the one from which both *Sputnik* vehicles and ICBMs are launched. Air Force radar has been monitoring the launching of large vehicles at this base from radar sites at Samsun, Turkey, in the Elburz mountains north of Tehran, and a third position north of Meshéd, Iran.

These locations make it possible to pick up the missiles as they reach an altitude of 35 miles over Kapustin Yar, while they are still rising vertically, and track them along the entire southern test range, which extends 1500 miles into the uninhabited desert northeast of Lake Balkash. The entire range extends over uninhabited areas and roughly parallels the southern frontier of the country. This makes it possible to keep the range under surveillance from Turkey and Iran, using the long-range radar developed for the Air Force.

The distance from Samsun to Kapustin Yar is less than 700 miles, and from the Elburz mountains to the Russian base, 875 miles. The site north of Meshéd is in a range of mountains rising to 10,000 feet, which forms the southern border of Russia. From this mountain range to the missile test range the terrain is flat and the effect is similar to that of looking down from the top row of a football stadium. From this last location, the entire downrange section of the test area can be monitored.

(The situation is not unlike that in this country, where the Air Force Missile Test Center at Cape Canaveral is monitored on occasion by the Millstone radar at Westford, Mass.)

The Soviet missiles are first detected when they soar above 35 miles altitude, still rising vertically. A fix is obtained by the Samsun and Elburz radars at this point and then the missile is followed down the length of the range. Data on performance is then sent back to the Pentagon.

The launching site itself is located on the edge of a semidesert east of Stalingrad and downriver on the Volga. Despite the apparently illogical setting for such an installation, Kapustin Yar is well-suited for its role. The huge industrial center of Stalingrad, with its rail, air and water transportation facilities, its heavy industry and electronics plants, is only 60 miles from the launching base.

The actual launching area, however, is on the edge of the sparsely inhabited semidesert of the Caspian depression. East of Kapustin Yar there stretches a generally uninhabited area of the USSR that is largely desert and mountains. However, in order to launch the *Sputnik* vehicles from this site, which the Soviets did, it was necessary to

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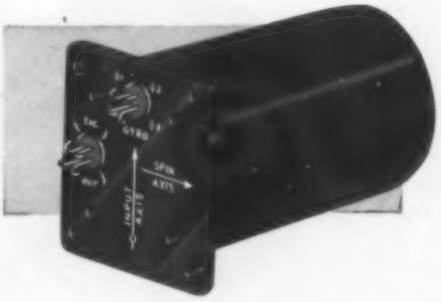

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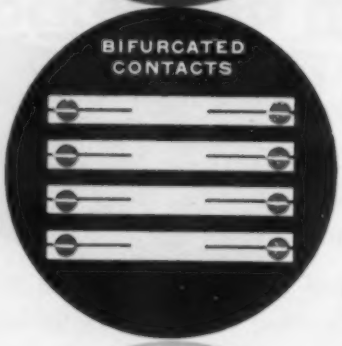

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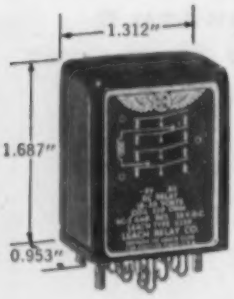

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guide the vehicles in a northeasterly direction, taking them over more populated areas. This was apparently a safe maneuver since the Russians were using proven reliable hardware.

The second-stage separation occurred over the area of the West Kazakhstan border near Aleksandrov Gay, and the third-stage separation occurred over the central Ural mountains west of Sverdlovsk. This latter region is more heavily populated than the southern test range, but insures that any failures occur over Soviet territory, rather than that of another country which might be tied to the United States.

This *Sputnik* test area is the same as that used to test the ICBM, which impacts on the Anadyr peninsula. The danger of a missile accidentally impacting in a nondesert area is about as serious as one of our missiles landing on one of the islands along our test range in the south Atlantic Ocean. The greatest portion of the Soviet range is in Siberia and tracking stations have been set up to keep tabs on test launchings.

Atlas, Thor, Jupiter Now Ready, Says Snyder

Murray Snyder, Undersecretary of Defense for Public Affairs, has stated that the United States now has three long-range missiles "ready to put in the field." He referred to *Jupiter, Thor* and *Atlas* during a speech in Cleveland, and later qualified the statement by saying that the *Thor* and *Jupiter* IRBMs will be in the hands of field troops "sometime this year." He added that the *Atlas* will be operational by the end of 1959.

Marconi Insts. Moves to Larger Facilities

Marconi Instruments has moved from New York City to larger quarters in Englewood, N.J. Company's new plant has demonstration rooms and increased space for engineering and shipping.

M-H Missile Division Opens February 1

Minneapolis-Honeywell Regulator Co. recently announced the formation of a Missile Equipment Division to consolidate the company's interests and activities in missile ground facilities. The new division will be located in Pottstown, Pa. and will be housed in a newly leased 150,000 square foot, former aircraft engine plant.

Equipment to be manufactured was described by M-H as automatic

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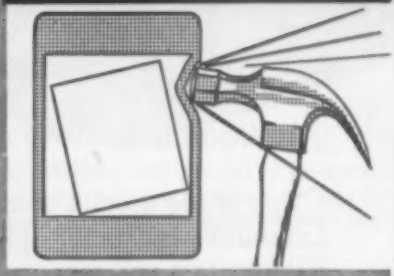

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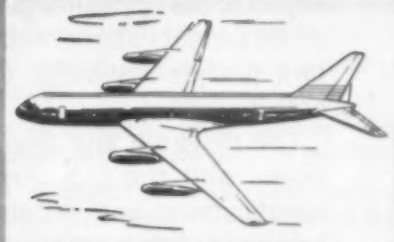

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control systems for ground facilities involving several prominent U.S. missile programs. Identity of the missile programs was not disclosed but company officials said that engineering, development and prototype manufacturing had been going on for some time.

Employment level was estimated at 150 by the end of 1958 with a future total of 400 or more.

M-H vice president H. F. Dever announced that Marshall B. Taft would be general manager of the new division. The Pottstown installation marks the 34th plant for M-H which has facilities in 10 states and five countries.

Soviet IRBM Bases Cover NATO Flank

An increasing number of reports are being received about the construction of Soviet IRBM bases in Bulgaria and Albania, designed to provide launching capabilities against NATO forces in that southeastern corner of Europe and throughout the Mediterranean. Almost the entire Mediterranean area, including many of our SAC bases in North Africa are within range of these weapons.

Soviet technicians are in the two countries supervising construction of the five bases and training personnel of the satellites' armies in use of the missiles.

Giannini Produces Workable Ion System

Giannini Research Laboratory, using helium gas as a working fluid, has achieved specific impulse ratings of 600 seconds with an ion propulsion system. Working with other ionized gasses, such as hydrogen, the laboratory feels that much higher figures can easily be produced, and a rating of at least 1000 can be obtained with helium by increasing the input energy.

The plasma jet used by Giannini developed temperatures in excess of 10,000°K (17,500°F). Continuous running plasmas were used in the experiments.

Chrysler Forms New Missile Division

Chrysler Corp. has announced the formation of a separate missile division which will be responsible for the company's participation in development, engineering and production of *Redstone* and *Jupiter* missiles. The new division was formerly known as Missile Operations.

Chrysler's announcement came only three weeks after the award of a

new $52-million contract for *Redstone* and *Jupiter* missiles.

T. F. Morrow, vice president and group executive for defense and special products, said: "Organization of a separate missile division is a result of our increased participation in the nation's missile program." He concluded with the statement that Chrysler has been associated with *Redstone* since 1952 and with the *Jupiter* since 1956.

Soviet Subs Active in Western Pacific

The Navy has revealed that Soviet submarines are cruising more and more openly in Far Eastern waters near our oversea bases in that area. However, it was emphasized that the submarines, which the Navy "assumes" are armed with missiles of several hundred miles range, have not violated any territorial limits and certainly have every right to be where they are. The Navy was commenting on a story that Soviet subs, capable of launching nuclear missiles, have been sighted on at least three separate occasions in the area.

Industry, Services Aid Amateur Rocketeers

Slowly but surely some effort is being made to organize and help the rocket and missile engineers of tomorrow who are amateurs today. Industry now contributes money and manpower —the former in the form of checks to aid local projects, the latter in the form of the spare time of its engineers and scientists who guide and monitor projects. For example, the National Capital Section of The American Rocket Society recently contributed $100 to a Wakefield High School project, where Diversey Engineering has also agreed to supply a static test stand for the

Mockup of AF IRBM Launching Site

Mockup of THOR IRBM operational launching site at Douglas' Culver City, Calif., plant. Missile is positioned on erector-transporter with its umbilical lines connected in a simulated launching countdown. THOR's operational nose cone can be seen at left. Guidance vans are upper center; liquid oxygen and helium tanks are behind missile; helium tanks are left of nearest revetment; and fuel storage tank is seen at lower right.

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group's small rocket motors. Aerojet-General and others have made similar contributions.

Meanwhile, the military—Army, Navy and Air Force—have all taken steps to supply these groups around the country with firing range facilities. Army, for example, through the efforts of Lt. Col. C. M. Parkin, Engineers Research and Development Laboratory, Fort Belvoir, has on several occasions made the facilities of Fort A. P. Hill, Va., available for Saturday firings. This facility has a range extending up to 30 miles.

Similarly, Navy has permitted some amateur firings from its Wallops Island range in Virginia. For the Air Force, Kendall K. Hoyt, executive secretary of Associated Missile and Rocket Industries, a trade association of missile and rocket manufacturers, is striving to get the Air Force and/or the Department of Defense to sponsor a national program for organizing amateur rocketeers on a national level.

The object of these efforts is two-fold: to generate interest in the field, and to see that all amateur rocket work is monitored closely enough so as to prevent serious accidents. Already a number of states have passed laws outlawing the firing of amateur rockets.

AFOSR Symposium Set for April by IAS

The Institute of Aeronautical Sciences will sponsor its Second Annual AFOSR Astronautical Symposium April 29-30 in Denver, Colo. The symposium will cover such subjects as space environment; vacuum-chamber research; control and propulsion of vehicles; departure, space navigation and re-entry; and the moon. A panel discussion will assume a capability for a manned space operation to discuss the question: "For what purposes should a manned space operation be utilized?" A report on *Far Side* will also be made.

AMF Will Close Boston Electronics Plant

The Boston electronics plant of American Machine and Foundry Co. will be closed and its work assigned to AMF facilities at Greenwich, Conn., and Pomona, Calif.

Dr. Wendell P. Sell, formerly general manager of the Boston operation, becomes division vice president with headquarters in Pomona, where Associated Missile Products Corp. will become a unit of AMF's electronics operations. Associated Missile Products Corp. was formerly a subsidiary of AMF.

washington trends

by Elizabeth Oswald

THERE WILL BE A LONG HARD FIGHT to make the Advanced Research Projects Agency an operating arm of the Office of Secretary of Defense. The following objections to the agency are being heard with increasing frequency from the Air Force and the Navy, as well as from industry: It would represent a duplication of effort, interpose a new layer which would increase the difficulties of communication and delay the making of decisions, and increase the drain on existing pools of scientific manpower.

AIR FORCE AND ARMY ARE STUDYING the implications of Defense Secretary Neil McElroy's decision which gives the job of developing the missile detection system to the AF and the job of developing the anti-missile missile to the Army. Opinions range from the belief that the decision has no impact on the basic mission of the AF to provide air defense, to the belief that in essence the decision turns over the principal responsibility for air defense to the Army.

Still another group argues that since the safety of the United States is at stake, at least as much effort should be provided for defense weapons as has been provided for strategic weapons. They add that a very real danger exists as a result of the decision to rely on the potentials of a single anti-missile missile, without the back up provided by the development of an additional system.

PRESENT ESTIMATES INDICATE that currently planned squadrons of intermediate-range ballistic missiles will consist of 15 missiles at an estimated cost of $41 million a squadron. The figure does not include development costs, missile warheads or land acquisition and training. In the case of the ICBM, plans call for 15 missiles on station at an average cost per base of $290 million, exclusive of missile warheads, land acquisition and training.

Because a solid-propellant successor to *Thor* and *Jupiter* is being planned, the indications are that Defense Department may not authorize the production of "very large quantities of these missiles," according to Defense Secretary Neil McElroy.

AF IS PUSHING HARD for permission to accelerate the *Titan* program. It wants about $29 million in additional funds for this purpose in fiscal 1958 and an additional $100 million in fiscal 1959. Accelerated development of the *Titan* boosted for use with the X-15 research plane would speed the development of manned missiles or satellites, according to testimony offered to the House Defense Appropriations Subcommittee.

MISSILE DETECTION SYSTEM will be a $721-million program. Radio Corp. of America is the prime systems contractor, with General Electric and Western Electric participating. Three sites are to be provided for missile detection, one of which will be in Canada. System is predicated on development of high-powered transmitters necessary to obtain a detection range of 3000 miles. First RCA contract is expected to be just under $500 million.

BELL AIRCRAFT CO. is making an air-to-surface guided missile for the Convair B-58 *Hustler*. The missile is apparently a new one, and not a modification of the Bell-built *Rascal* which is to be carried by the B-47 medium bomber and for the time being by the B-52. Existence of the missile is confirmed by Maj. Gen. Bernard A. Schriever, chief of the AF Ballistic Missile Agency, and ends speculation as to the purpose of the pod which the B-58 carries.

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Astrionics

by Henry P. Steier

On the day before Christmas, U.S. satellite tracking stations were alerted for the appearance of *Sputnik* III or on Christmas day, USSR moon rocket I. Secret information was apparently available that the Russians were ready to try a holiday "coup." Looks as though the attempt failed, indicating others, too, have problems.

•

United Nations source reports a satellite conversation with a USSR representative to the UN Assembly. The Russian was asked how many tries his country had made before they got *Sputnik* I up. "Perhaps 30," was the reply. Pentagon sources say they know of 16 tries. So, it could be that the U.S. has a long way to go.

•

Project *Vanguard* planners expect the Russians will stick with their 20- and 40-megacycle frequencies for satellite transmissions. Wherever the U.S. real estate situation permits use of the much larger area needed for suitable 20- and 40-mc tracking antennas, we are putting them in. Tracking station unit going to Union of South Africa will be equipped with the lower frequency antennas for tracking Russian signals as well as the 108-mc kind we'll use.

•

A unique "weapon system" with which the Russians confront us is the Soviet All Union Institute of Scientific and Technical Information. With a staff of 2300 specialists, supplemented by 20,000 students and engineers who act as part-time translators and abstractors, its function is to make available to the entire Soviet technical community information from 10,000 journals published in 80 countries.

This information comes from Stanford Research Institute, which says no comparable effort exists in the United States nor in the rest of the Free World, and that continued vitality of scientific progress may demand a solution to the information access problem. We need a national technical information center. Prominent U.S. scientists have reportedly said the best way to find out what American science is doing is to read the Russian literature. Our technical community is drowning in the flood of information and literature it is producing. Situation demands an organized attack on problem of collection, translation, abstraction, codification, storage and dissemination.

•

Marriage of Stromberg-Carlson's Charactron-shaped beam electron tube and the Haloid Company's Xerox method of rapid printing to produce the world's fastest print-out of computer data ought to be a bottleneck-breaker in getting missile data faster. Numbers, letters and symbols on the Charactron's tube face are optically projected onto a Xerox printer drum. Result is a 4680-line-per-minute printing capability. This is up to 10 times faster than electromechanical printing.

•

IRE's Professional Group on Telemetry and Remote Control are thinking about a name change for the group. Present name does not adequately emphasize control aspects of missiles, it feels, and new name might be Missile Electronics and Telemetering or Astronautic Electronics and Telemetering.

•

That annual institution, the highlight session of the IRE National Convention, usually held in the evening, will be devoted this year to space electronics. Discussion program is intended to take the electronics engineer on a trip through space to describe the environmental problems he will encounter. On hand for the panel discussion will be von Braun, Ehricke, Stuhlinger and Whipple.

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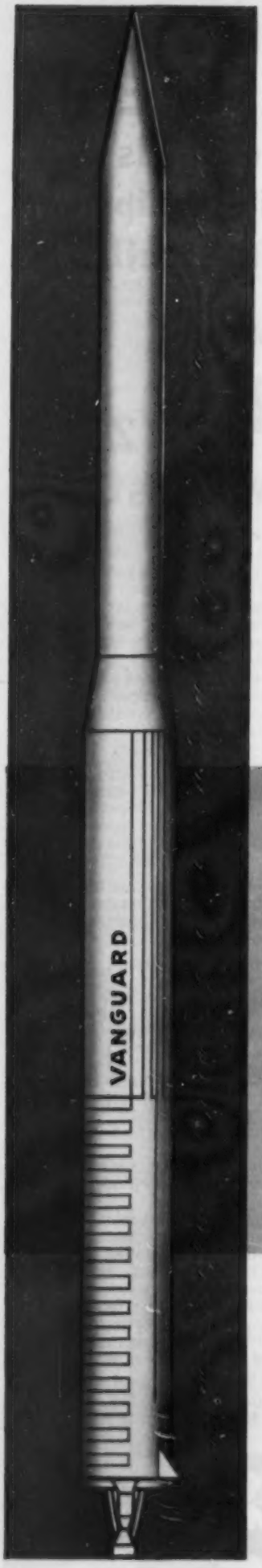

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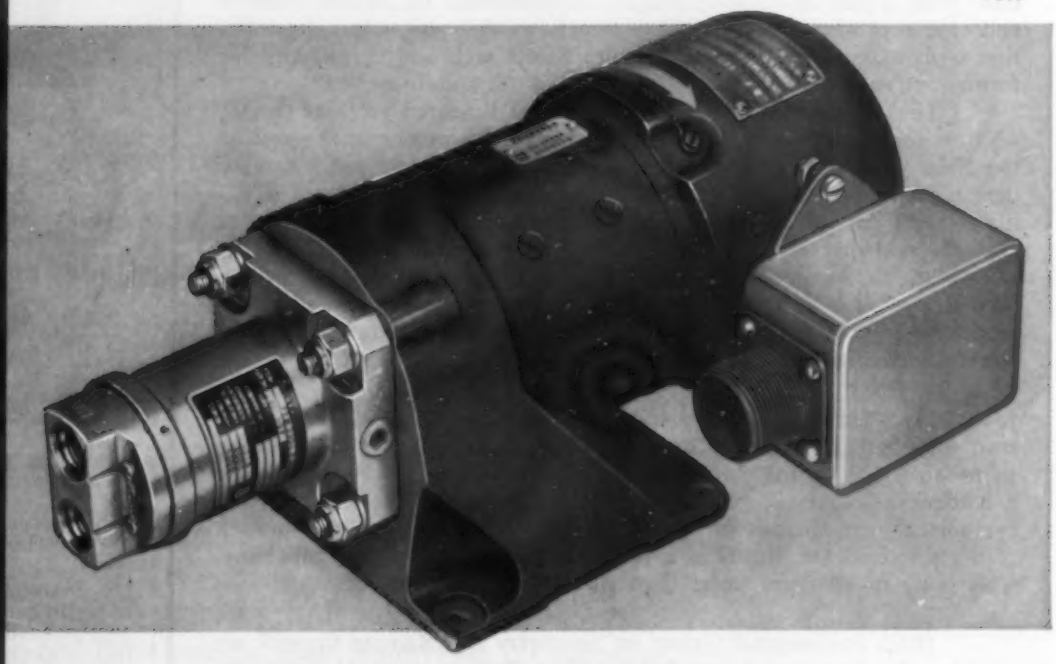

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Missile Business

by Seabrook Hull

A major missile business problem is corporate planning for the future. This involves not only market analysis but such things as future changes in government contracting regulations, renegotiations policies, the proper balance between commercial and defense business (excepting those companies, of course, which rely 100 per cent on federal business), etc. Right now, the missile business is in a complete state of flux in every respect. The only thing that is certain is that money for missiles, rockets and space flight is in for a major expansion. Along what lines and at precisely what rate remains to be determined.

The shock of *Sputnik* has now given way to confusion over just what must be done and how fast. The Administration remains strongly confident of the U.S. position. The consensus of Congress, in contrast, is that the United States is still not on the right track. The result of this difference of opinion between the executive and legislative branches of government is that over the next six months the differences will be thrashed out on Capitol Hill with the benefit of the decisions going to Congress. To be decided are such things as the balance between missiles, space flight and "conventional" weapons, R&D, roles and missions, other balances between Army, Navy, Air Force and other agencies that may be established.

All of these things affect corporate planning. And, now is the time to influence decisions which will set the rules of the game for years to come. For example:

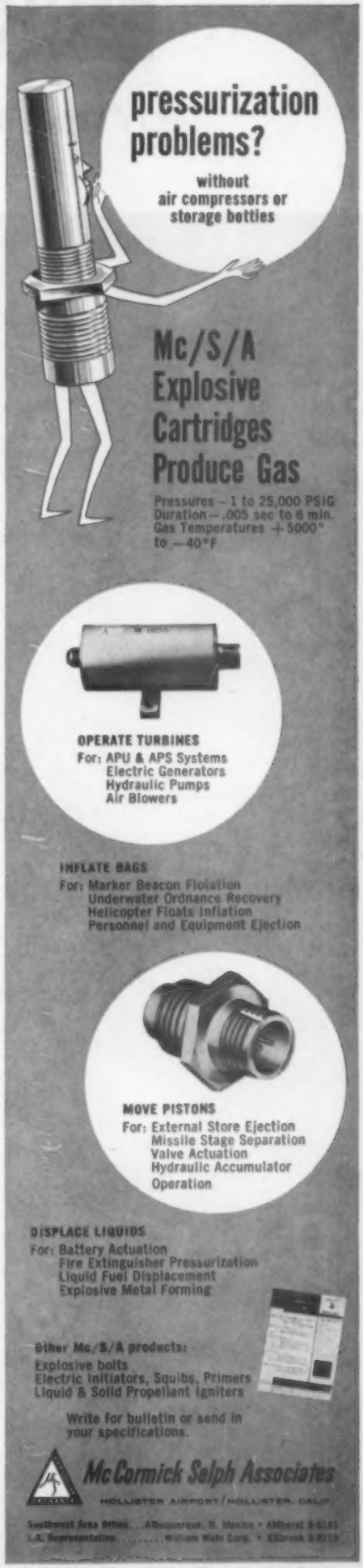
RENEGOTIATION—The present act is due to expire December 31, 1958. Changes are being proposed now, such as speeding up handling of cases and giving small business a better break on rulings. Now is the time to make your views known to Congress.

ARMED SERVICES PROCUREMENT REGULATIONS—Modifications of these are being made constantly, but there are signs Congress is going to take a really probing, critical look this year to force more advertised bids, a better guarantee of performance under contract terms, simpler, speedier procedures, etc. Again, if you've got anything to say, say it now, before new laws are already enacted.

PATTERN OF EXPANSION—This, in broad terms, boils down to how much money for missiles, space flight and conventional weapons. In more detail, it means an analysis of solid versus liquid propellants; small rockets against big; preference between passive and active, command and integral guidance; future of materials—plastics vs. metals, for example—etc.

Actually, the trends are available but not readily. Technologically, they can be traced ahead. But they are subject to political pressures, too. In this period, more than ever before, make your Washington representative work. There's a lot he can give you if he digs long enough and deep enough. The stuff's there—just buried.

The proper ratio between defense and commercial business is a matter of widely varying opinion. Some companies, such as American Machine and Foundry, prefer to hold defense to 20 per cent or less of their gross. Others, like The Martin Co., evidence no real interest in commercial business at all. There are a great many pro's and con's both ways. However, a stable and substantial commercial activity is probably a good stabilizing factor in the rate of doing business of any company—a matter of undoubted interest to the stockholders. More on this next month.



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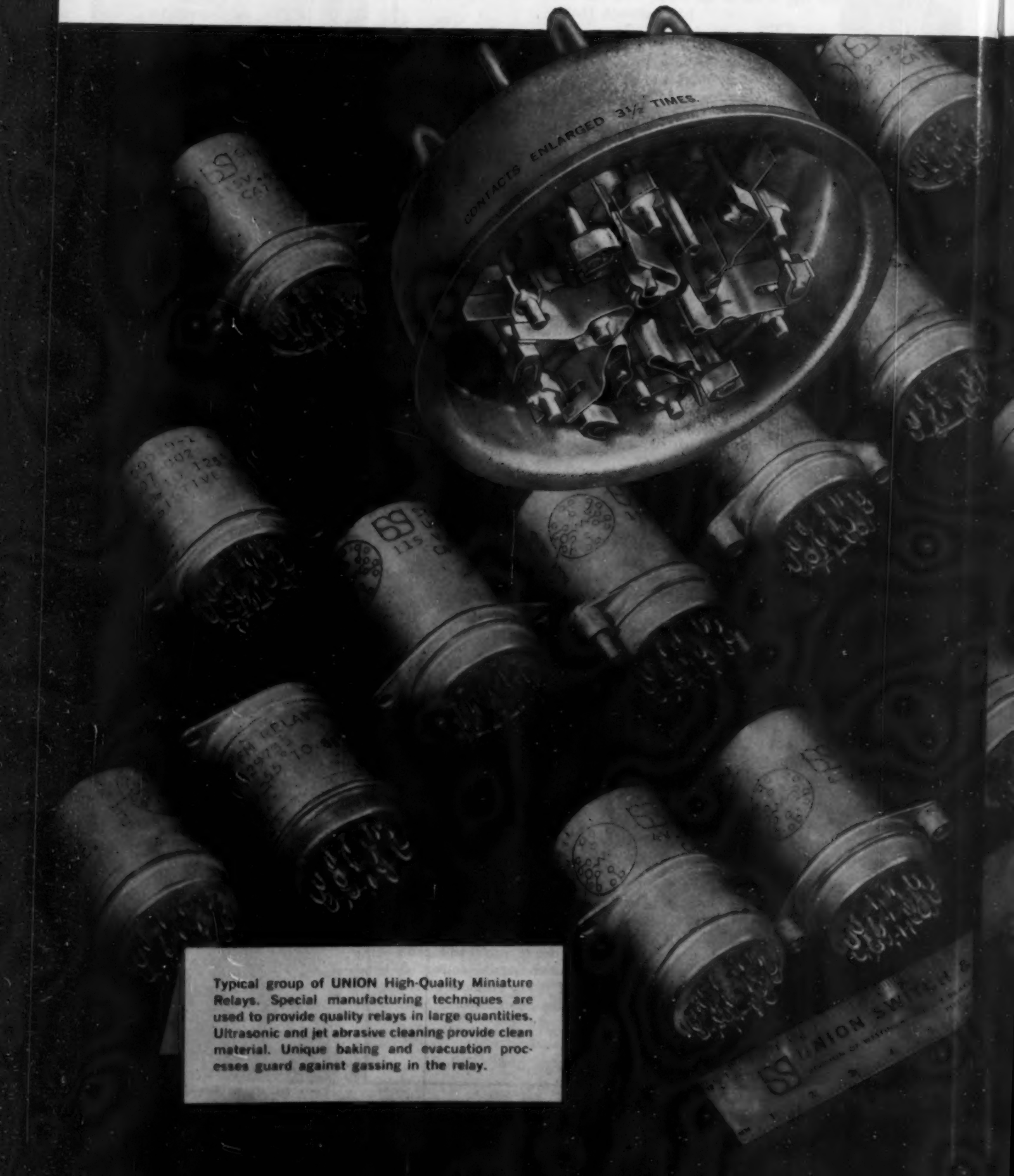

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4. AC or DC Models Nominal operating voltages from 1.5 to 160 volts DC; 115 volts, 60 to 400 C.P.S., AC. AC relays incorporate built-in rectifiers and have same reliability as DC relays.

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6. Special Relays *Slow-acting relays* for applications requiring a differential between operate time of various relays; *Plate-circuit relays* which operate on less than 8 milliamperes; *Double-coil relays* with each coil enabling operation of the relay . . . available on special order.

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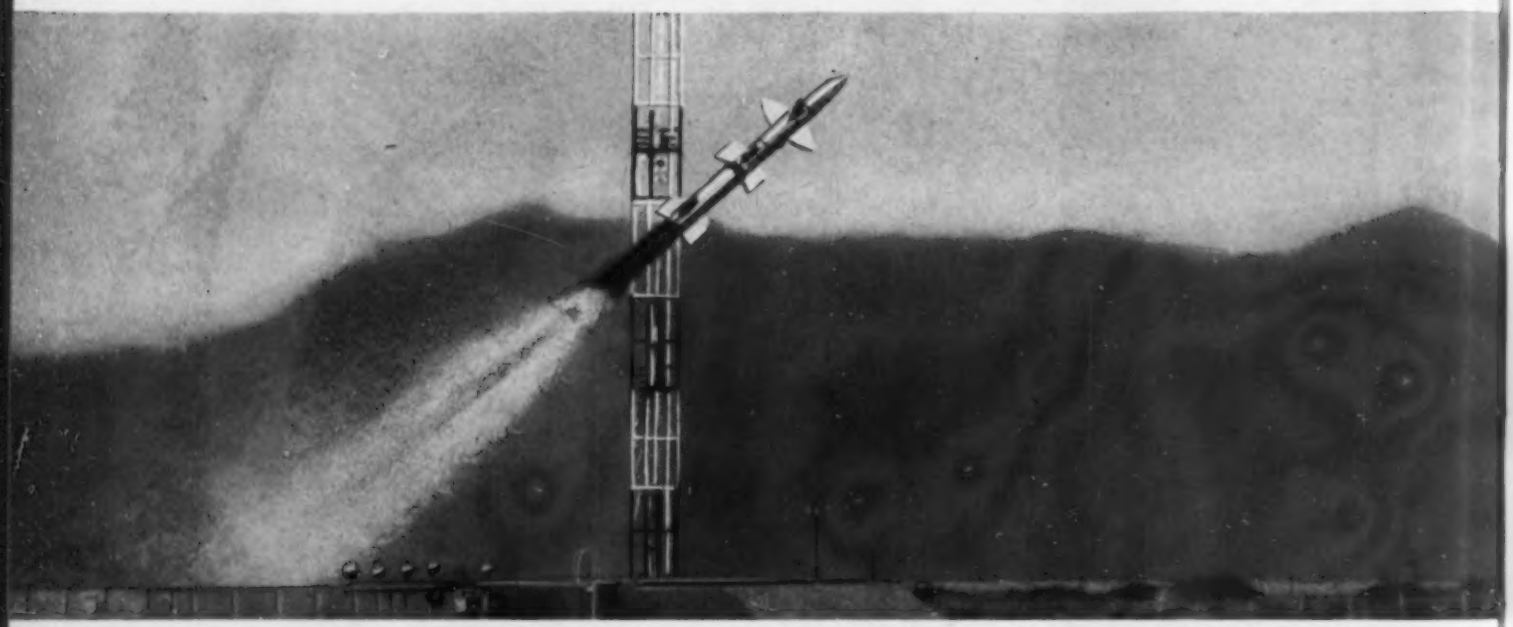
TALOS



This Talos launching from the RCA Defense System on Dec. 13, 1957, resulted in direct hit on distant drone plane.

The RCA Talos Defense System is the first *completely automatic* land-based system for launching and guiding missiles, and utilizes the Talos Missile developed by the Applied Physics Laboratory and produced by Bendix. The Defense Unit receives target signals from remote outposts, analyzes them with regard to number of attackers, location, course and speed. Next, computers determine the logical points of interception, order the missiles loaded on launchers, guide them at supersonic speed to the vicinity of the target, after which the missiles "lock" on the target and close in for its destruction. All without even the touch of a button! The RCA Talos Defense System, with its electronic equipment and guidance systems, was designed, developed and built by RCA as prime contractor, aided by many subcontractors. It was turned over to the U. S. Army on October 15, 1957, and is a missile milestone, exemplifying the continuing determination of American enterprise to secure peace with honor and justice.

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DEFENSE ELECTRONIC PRODUCTS

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VOL. 3 NO. 2

FEBRUARY, 1958

missiles and rockets

MAGAZINE OF WORLD ASTRONAUTICS

missile electronics procurement exceeds $3.5 billion annually

Hundreds of Firms Entering Field

by Selig Altschul

RUSSIAN SCIENTIFIC advances inevitably are leading the United States toward greater emphasis on missiles and stepped-up programs in electronics and related activities. This spells a far higher level of expenditures for these items by 1961 than previously projected by the military.

Air Force, for example, was on record before the *Sputniks* with an estimate that its expeditures for missiles were expected to increase from the $500-million level of 1956 to more than $2.8 billion by 1961. The gain in electronics was projected to almost double, reaching $1.3 billion by 1961.

These figures may now be considered low in light of recent developments.

Of major significance in these readjustments is the appearance of a host of new companies, large and small, with no previous formal identification with the aircraft and missile industry who are making their influence felt.

There are no accurate figures available as to the full measure of military electronic equipment sales volume. Many manufacturers in this activity are also in basic fields which they used as springboards to become interested in electronic-type activities. They include companies in business machines, electrical equipment, automotive products, heating and ventilation devices and commercial radio and TV. There are a multitude of small units (and even larger organizations) splintered off from giant corporations and proceeding in their own specialized channels, but their sales volume remains hidden in privacy.

One reliable estimate places military electronic spending by Department of Defense at more than $17 billion for the seven years through June 30, 1957. For the fiscal year 1957 alone, more than $3.5 billion is estimated to have been expended for this purpose. In this past fiscal year, more than $1 billion of this amount is estimated to have gone

Mr. Altschul is a leading aviation consultant and analyst.

Spending Reaches $273 Million in First Quarter

EIA Releases Figures on Missile Electronics Increase

Military spending for missile electronics totaled $273 million in the first quarter of FY 1958, according to statistics compiled by the Electronics Industries Association with its recently devised formula to determine that portion of military appropriations from all major defense procurement categories spent for electronics.

Intended primarily to depict trends, and subject to later revision, the EIA computation shows the following missile electronics figures (in millions of dollars) for the first quarters of fiscal years 1955-1958, all ending September 30:

	First Quarter FY 1955	*First Quarter FY 1956*	*First Quarter FY 1957*	*First Quarter FY 1958*
	$ 59	$115	$205	$273
Total electronics spending for the same period was:				
Budget Category				
Aircraft	$238	$299	$213	$340
Ships, harbor craft	19	17	17	23
Combat vehicles ..	15	26	2	1
Support vehicles ..	3	1	....	1
Missiles	59	115	205	273
Elec. & comm. ...	145	168	130	204
R&D	56	60	65	73
Miscellaneous	15	10	5	11
	$550	$696	$637	$926

directly into aircraft, another $1.1 billion into missiles and $880 million into electronics and communications.

It is evident that the growing electronics market is vital not only to the old-line aircraft company but is indeed most attractive to the many new entries.

As with all new "growth" industries, where initial spectacular successes have broken through and hold forth the hope of even greater triumphs to come, considerable speculative interest is aroused. In boom periods, this frequently eases the problem of attracting speculative funds to help finance these new enterprises. In such instances, there lurks the hidden hope that a new group of engineers or scientists may twist the electron to radical new adaptations as the microwave, sonar and radar were in their day. Should success crown the pioneering efforts, the rewards are indeed rich to those who had the foresight and courage to get in on the "ground floor." But, while the possible gains may be higher, the risks are even greater under such circumstances.

Yet, there are quite a few companies, formed in recent years, who have at least established a firm foothold in this new burgeoning industry.

The facets of missile and weapon systems development and production are so varied that literally thousands of companies have laid claim to being engaged in activities in this field. They range from companies developing countermeasures of a highly secret nature, down to a prosaic custom machine shop. A veritable "jungle" exists in any attempt to subject companies in this field to the processes of orderly analysis as is common in most established industries.

The accompanying table of companies interested in some phase of electronic controls or missile activity is but a partial list of those engaged in this field. Many hundreds more, mostly small units, could be added. Most of these larger companies have numerous other interests, and electronic developments for the military are but minor sidelines at the moment.

The fortunes of individual companies in this group are impossible to assess unless it can be ascertained with a high degree of certainty what importance can be attributed to product lines to be incorporated in military programs likely to prevail. This takes some doing.

In the first place, the course of overall programs has been rather fluid and will remain so to a large degree. Many individual companies are precluded from revealing any important details as to the type and volume of work which is in the secret area. While research contracts hold the promise of successful developments, they carry little, if any, profit. Their main advantage, of course, is to hold together skilled research teams. Earnings of any consequence generally come from volume production contracts. And even when production is under way, as new technological developments may dictate, programs can be cancelled.

There will be more casualties as the industry shakes itself out. And, in this process, earnings will have to come along to support equity values. In many instances these equities are now selling at inflated levels—in anticipation of market conditions yet to be realized.

On the other hand, there will be other situations where depth and perseverance of pioneering research efforts will lead to profitable production, justifying enhanced equity valuations now and in the future.★

Companies in Various Phases of Electronic Controls or Missile Activity

ACF Industries
Admiral
Aerovox
Airborne Instruments
Aircraft Radio
Air Products
American Bosch-Arma
American Electronics
American Machine & Foundry
American Tel. & Tel.
Amphenol Electronics
Arvin Industries
Avco
Beckman Instruments
Belock Instrument
Bendix Aviation
Bridgeport Brass
Burroughs
Chrysler
Clarostat Mfg.
Collins Radio
Columbia Broadcasting
Consolidated Electrodynamics
Consolidated Electronics
Cook Electric
Cornell-Dubilier
Craig Systems
Daystrom
A. B. Du Mont Labs
Eastern Industries
Eastman Kodak
Edo
Eitel-McCullough
Electronics Corp. of America
Elgin National
Emerson Radio
Federal Mfg. & Engr.
Firestone
Food Machinery
Ford Motor
Freuhauf Trailer
Gabriel Company
G. M. Giannini & Co.
General Dynamics
General Electric
General Instrument
General Motors
General Precision Lab.
General Tire
Goodyear
Hercules Powder
High Voltage
Hoffman Electronics
Hycon Mfg.
International Business Machines
International Resistance
International Tel. & Tel.
Interstate Electronics
Jerrold Electronics
Lear, Inc.
Litton Industries
Magnavox
P. R. Mallory
Marquardt Aircraft
W. L. Maxson Corp.
Midwestern Instruments
Minneapolis-Honeywell Reg.
Motorola
Muter Co.
National Cash Register
National Co.
Norden-Ketay
Packard-Bell
Parker Hannifin
Perkin-Elmer
Philco Corp.
Pyramid Elec.
Radio Corp. of America
Raytheon Mfg.
Robertshaw-Fulton
Robinson Aviation
Sanders Associates
Sangamo Electric
Servomechanisms
Skiatron Electronics
Sperry Rand
Sprague Electric
Square D
Studebaker-Packard
Sylvania Electric Prod.
Tel-Autograph
Telecomputing
Texas Instrument
Thiokol
Thompson Products
Tracerlab
Tung-Sol
Varian Associates
Westinghouse
Zenith

m/r exclusive:

1958 Missile Guidance Roundup

a report on missile guidance systems and industry participation

by Heyward E. Canney, Jr.

THE SIGNIFICANT aspect of a guided missile is that it is directed or otherwise constrained after release and during some portion of its flight to the target. There is some tendency, while pondering the rakish sweep of the airframe and the deafening roar of the motor, to forget that the successful weapon could not exist without having built into it some sort of artificial intelligence.

Compared to a human being, the most sophisticated missile is a mindless moron, but in contrast to other human artifacts it is fiendishly clever. The tactical missions of the various missiles are well known, as are the various helps and hindrances offered by the missile's environment. The differences are not completely clear-cut, but all missiles may be divided broadly into ballistic and aerodynamic.

As we and our enemies dwell in an atmosphere, all missiles, where possible, must use the aids that the atmosphere offers (aerodynamic support, oxidizer extraction, etc.) and evade the hindrances (friction heating, electromagnetic attenuation, etc.) that the atmosphere presents.

The physical globe of the earth influences the atmosphere to a certain extent and also affects the flight of any missile even in the absence of an atmosphere. The earth's mass presents a nominally fixed gravitational reference and restraint, and its curvature limits ultrahigh frequency radio guidance transmission, which is essentially line-of-sight. Its imperfect symmetry and its motions (notably rotation) influence the flight of all missiles, but most seriously affect the longest range missiles. All missile flight paths may be considered as portions of a theoretical arc of no particular length but which begins in friendly areas and ends in those of the enemy as shown in Fig. 2.

In Fig. 2, the composite arc begins at the left below the surface of the earth, in this case necessarily a water surface. It curves upward through the air, sometimes into space beyond, and eventually back to a point below the earth's surface, which again, is presumably a water surface.

At present, one cannot conceive of an underwater-to-underwater missile of long range, which achieves its mission over the aerial route but can only contemplate intersubmarine combat with

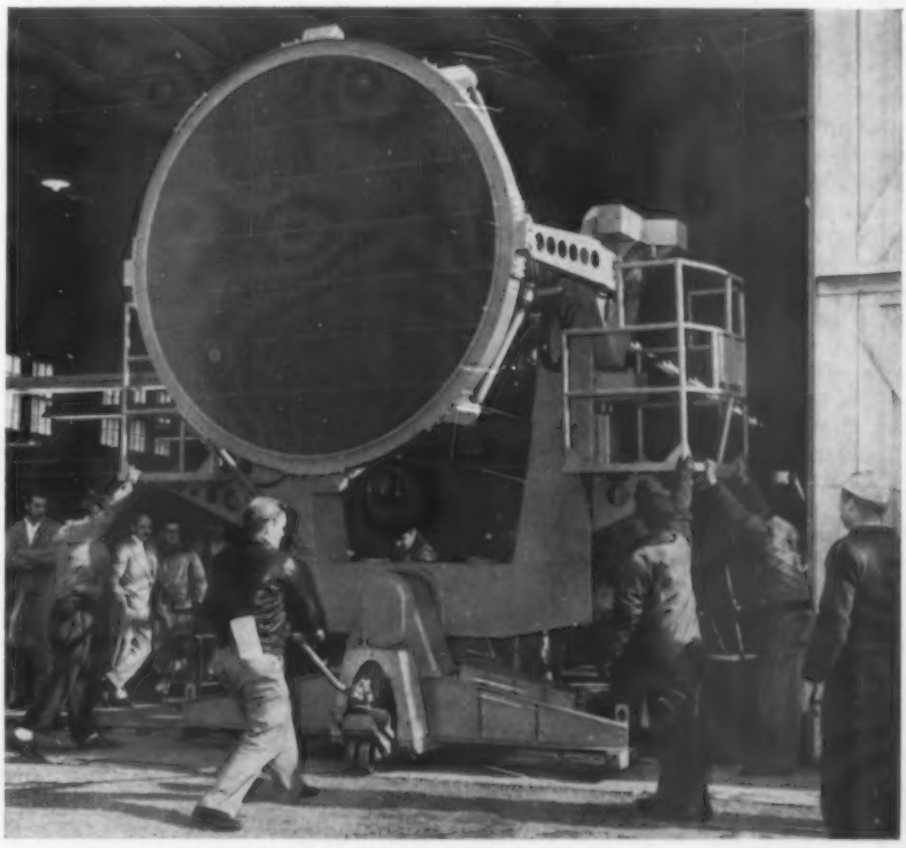


Fig. 1—MK 25 antenna, part of the Reeves-built radar director for the TERRIER.

The author is chairman of the board, General Astronautics Corp., New York City, N.Y.

torpedoes, and this over the "short route." A surface-to-air missile occupies an early segment of the arc and an air-to-surface or air-to-underwater missile, a latter portion of the arc.

Now, the master concept of all warfare is to hit the enemy and destroy him in his homeland or as near to it as possible. Engagements farther along the arc back toward your homeland make your battle situation more serious. The enemy may hit you at any point along the arc; but if the main emphasis is at your end of the arc, you are in trouble.

Recognizing this, both we and the Russians are placing heavy emphasis on ICBMs and the far ends of the arc. Ironically, this also produces frantic efforts on the near ends of the arc to do something (anti-ICBMs) about a weapon which has an excellent chance of traveling the entire arc without interception.

In summary, the nature of a missile may be regarded as follows: A destructive payload is to be taken to a point and detonated. The payload is housed in an airframe which acts as a vehicle for it, for the propulsion system and for the guidance and control equipment. The vehicle may have wings or fins to exploit aerodynamic support during part or all of its flight for lift or maneuver. Acquisition radar may be used at long detection ranges, and tracking and commands supplied to the missile until it can home in on the target with its own equipment, and then explode by means of a proximity device. The overall philosophy of guidance depends to a great extent on range and on how directly the missile is to be supplied with data for commands.

The Nature of Targets

Considering the dynamical aspects of flight path and expected target locations, one or a number of guidance philosophies may be used. Although such generalizations are tricky, one may think of guidance as an intelligence system designed to draw information from the target directly or indirectly or from the gross environment, either singly or (more often) in combination.

Drawing information directly is easiest with aerial targets which are usually quite distinct from the background. This procedure is well-known as "homing" and capitalizes on sound and such electromagnetic radiations as

Table I: GUIDANCE SYSTEMS

(arranged by mission and type)

Type	Name	Prime Contractor	Guidance Contractor	Customer	Guidance Type	Max. Range (naut. mi.)	Logical Warhead
SAM	Bomarc	Boeing	Westinghouse	USAF	RC, ARH	300	Atomic
	Hawk	Raytheon	Raytheon	Army	RC	22	Explosive
	Nike-Ajax	Western Elec.	Western Elec.	Army	BR	25	Explosive
	-Hercules	Western Elec.	Western Elec.	Army	BR	50	Atomic
	-Zeus	Western Elec.	Bell Labs.	Army	BR	100	Atomic
	Talos	Bendix	RCA	BuOrd	BR, SARH	50	Explosive
	Tartar	Convair		BuOrd	BR	30	Explosive
	Terrier I	Convair	Reeves	BuOrd	BR	10	Explosive
	Terrier II	Convair	Motorola	BuOrd	BR	20	Explosive
AAM	Ding-Dong	Douglas	Hughes	USAF			Atomic
	Falcon I	Hughes	Hughes	USAF	RH	6	Explosive
	Falcon II	Hughes	Hughes	USAF	IRH	6	Explosive
	Genie			USAF			Atomic
	Sidewinder	Philco	GE & Philco	BuOrd	IRH	6	Explosive
	Sparrow I	Sperry	Sperry	BuAer	BR	6	Explosive
	Sparrow II	Douglas		BuAer	BR	7	Explosive
	Sparrow III	Raytheon	Raytheon	BuAer	BR	7	Explosive
ASM	Bullpup	Martin	Martin	BuAer	RC	20	Explosive
	Rascal	Bell Aircraft	Federal	USAF	RC	100	Atomic
AUM	Petrel	Fairchild	Fairchild	BuOrd	RC	20	Explosive
SSM	BALLISTIC:						
	Atlas	Convair	GE	USAF	RC/IG-stellar	5,000	Hydrogen
	Corporal	JPL	Gilfillan	Army	RC	150	Atomic
	Jupiter	Chrysler	Ford Instr.	Army	IG	1,500	Hydrogen
	Polaris	Lockheed	GE	Navy	IG-stellar	1,500	Hydrogen
	Redstone	Chrysler	Ford Instr.	Army	IG	200	Atomic
	Sergeant			Army	IG		Atomic
	Thor	Douglas	AC Elec.	USAF	IG	1,500	Hydrogen
	Titan	Martin	Arma	USAF	IG	5,000	Hydrogen
	AERODYNAMIC:						
	Dart	ADC	Wagner	Army	Optical	2	Explosive
	Lacrosse	Cornell	Federal	Army	RC	8	Explosive
	CRUISE:						
	Matador	Martin		USAF	IG?	350	Atomic
	Navaho	NAA	NAA	USAF	IG-stellar	5,000	Hydrogen
	Regulus I	Vought		BuAer	IG?	250	Atomic
	Regulus II	Vought	Sperry	BuAer	IG?	300	Atomic
	Snark	Northrop	Northrop	USAF	IG-stellar	5,000	Hydrogen
	Triton	McDonnell		BuOrd	IG?	1,500	Atomic

Key:		Key:	
JPL	Jet Propulsion Laboratory	RC	Radio command
ADC	Aerophysics Development Corp.	ARH	Active radar homing
NAA	North American Aviation	SARH	Semiactive radar homing
RCA	Radio Corporation of America	BR	Beam-rider
GE	General Electric Co.	RH	Radar homing
AC Elec	AC Electronics Division (Div. AC Sparkplug)	IRH	Infrared homing
		IG	Inertial guidance

light, heat and radio. Currently, infrared (IR) and radar are highly favored. Homing systems are of three types—passive, semiactive and active.

Homing Systems

Passive systems merely absorb energy and use this to supply corrections to the flight path, and have the advantage of not telling the enemy a missile is coming. Infrared is of this type, using the energy radiated from exhaust pipes of reciprocating engines and the nozzle plume of a jet or rocket.

Because of the electromagnetic frequencies involved and the short ranges over which such systems work, IR guidance systems are light, cheap and accurate. Infrared is hard to conceal or reduce in radiative intensity, and is thought to have an even more spectacular future than its present use would indicate.

A compromise with passive methods is called semiactive homing. Here you supply the radar energy from a point outside the missile to bounce off the target and back to your missile, which is equipped as though the enemy were cooperating with you. Your missile then homes in on the target in the same way as with IR, but at a different frequency.

The hazard here, however, is that while the semiactive homing missile does not announce itself any more than the passive missile, the source of radar energy, without which it cannot operate, does announce itself and becomes a high-priority target.

Active homing involves a completely self-contained system. The missile carries its own source of radar with it, takes a chance on being detected and shot down, and uses the reflected radar energy (from its own transmitter) in somewhat the same way as the passive system.

Missiles using homing alone are short in range, generally fired at aerial targets in salvos and are apt to be small and cheap. Whether IR or radar is used depends partly on the tactical situation and partly on the weather.

External Guidance

Since missiles which obtain their guidance information solely from the target are limited in range, and it is desirable to intercept enemy targets "as far back on the arc" as possible, direct target-sensing equipment is supplemented by indirect intelligence. It is possible to lengthen the range of a surface-to-air missile, for example, by increasing the power and complexity of its active radar-homing system, but the requirement of producing many large missiles to counter mass attacks makes the idea economically unfeasible.

Guidance from the point of origin is thus used. Since light and sound are seriously limited in range, the remaining practical agency is active radar. The hazard of enemy detection and counterfire is immediately reintroduced. However, this is treated by using such strategems as random timing and frequency and electronic countermeasures (ECM) to jam enemy radar receivers or cause confusion by the illusion of certain activities not really engaged in, and through physical dispersion of launching and guidance sites.

The point of origin is likely to be on the ground, but may be in an aircraft. Guidance from the point of origin by radar uses two philosophies—beam-riding and radio command.

Beam-riding is the simpler of the two, and involves two radars, one of which is kept constantly pointed at the target. The second receives the target, tracks it and provides a path for the missile. The point of origin may be stationary and the target moving, or vice versa.

In either case the missile is launched, maneuvered into the second radar beam and, once there, is caused by its guidance system to stay within the beam. In either case the path of the missile will be curved. There is not much point in this system if the origin and target are both stationary.

The other major radar-guidance type is radio command. It used two tracking radars and one command radar. Here the target-tracking radar works with the missile-tracking radar, feeding data into a computer which formulates commands to be sent to the missile over the third radar. In other words, this system observes the behavior of both target and missile and decides what is to be done to bring them together in space.

This system is not necessarily any better than the beam-riding system, and is considerably more complex. It has the advantage of placing less strain on the maneuvering (and bending) limits of the attacking missile, but has the disadvantage that only one missile at a time may be accommodated.

Aids to Guidance

As target ranges get longer, tracking radars must be supplemented with other radars—known as acquisition radars—to acquire the target. They detect the existence of a potential target, identify it as a dangerous one, and relay coordinative information to tracking radars, which then know the probable point at which the target will enter their operational distance threshold.

At extreme ranges, and with extreme target speeds, several stages of acquisition may be used. Radars such as these are used against potential enemy bombers and ICBMs.

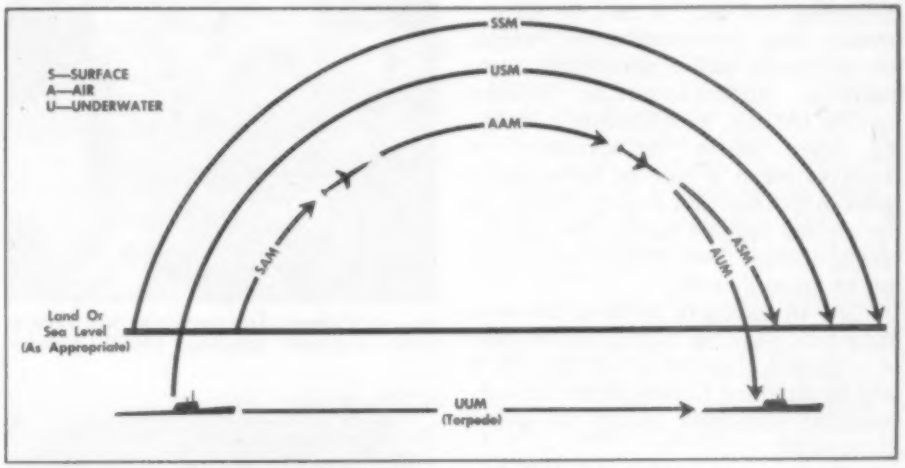


Fig. 2—Functional roles of guided missiles by types.

All targets are not aerial. In fact, ground targets may be considered the most critical targets from the offensive point of view. Without their destruction, no war can be won. Air-to-surface missiles are the bomber's compromise with the missile—bombing with a gliding propelled bomb steered from the bomber.

The bomber flies most of the way to the target, releases the missile at the original or alternate target, and remains outside the lethal radius of antiaircraft fire. The bomber functions as additional stages of rocket vehicles.

Guidance problems occur not only over visibility of the target to radar or other sensing agencies, but the fact that the ground target is by no means as distinct from the background as with an aerial target. It is more difficult to tell whether what has been selected as the target actually is what you want.

Homing systems such as IR, intended to home on the heat of a factory, may be induced by decoy means to home in on something else and spare

the factory, and so on. Although the missile may have radar and other sensing agencies carried inside, there is likely to be quite an array of additional equipment in the carrier aircraft to enable human operators to make spot decisions on how to direct the missile.

The Ultimate Artillery

Short-range missiles, designed for use against ground targets, may augment the artillery philosophy with cruciform wings for easy maneuverability against moving targets like tanks. These hybrid birds seem to be half ballistic and half aerodynamic, but are here termed "aerodynamic" to distinguish them from other missiles, which fly essentially like airplanes.

Airplane-type missiles are called cruise missiles and fly like sophisticated "buzz bombs." They are equipped with autopilots, certain devices for radio command, and may, if they fly for extremely long (intercontinental) ranges, use automatic stellar navigation. Summarizing, surface-to-surface missiles may be ballistic, aerodynamic or cruising types (where "aerodynamic" is taken to mean a sort of compromise between ballistic and cruise), which use the air for support mainly for maneuvering, though these distinctions should not be taken literally.

As an analog to artillery, the most immediate problem facing the designer of a guidance system is survey, which may be anything from accuracy in conventional battlefield survey to global cartography.

Both extremes have as their objective the exact determination of the location of the target with respect to the launching point. Until this is established with an acceptable degree of precision, the idea of a surface-to-surface missile, or even the use of conventional artillery, is futile.

In the shorter ranges, this is largely a matter of quick and accurate battlefield survey, but with the larger ranges there is some doubt that an ICBM with a perfectly operating guidance system would hit the target. The uncertainty of the target location is about the same as the circular probable error of dispersion of the nominally perfect missile sent there. A series of theoretically absolutely perfect shots might simply dig the same crater bigger and bigger at a point, say, 11.27 nautical miles east-northeast of the target, where nothing was in error but the conclusions of the best available cartography.

A cruise missile may be thought of as an expendable pilotless bomber which flies like an airplane, steadied by an airplane-like autopilot, guided by airplane-like (but self-operating and automatic) celestial navigation, and diving into the target like a kamikaze.

Table II: DIVISION OF MISSILE ROLES BY SERVICE

TYPE	ARMY	NAVY	AIR FORCE
SAM	Hawk Nike-Ajax -Hercules -Zeus	Talos Terrier I Terrier II Tartar	Bomarc
AAM		Sidewinder Sparrows I-V	Ding-Dong Falcons I, II Genie
ASM AUM		Bullpup Petrel	Rascal
SSM	Corporal Jupiter Redstone Sergeant Dart Lacrosse	Polaris Regulus I, II Triton	Atlas Thor Titan Matador Navaho Snark

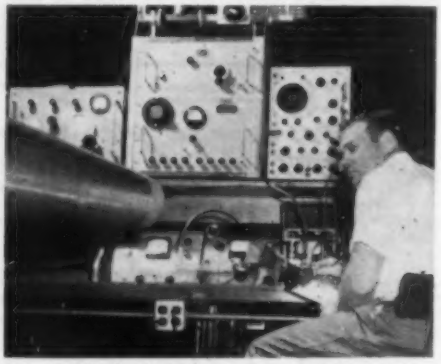


Fig. 3—Federal Telecommunication Laboratories engineer checking TALOS radome.

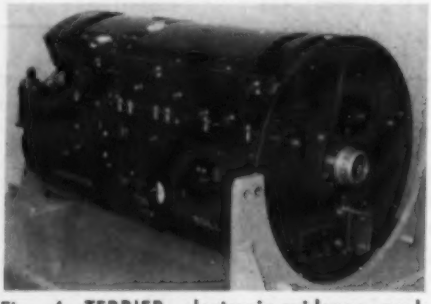


Fig. 4—TERRIER electronic-guidance package, developed and produced by Motorola.

Insofar as it has airplane-like attributes, it is affected more by the atmosphere than by the motions of the earth directly. It evades or exploits qualities of the atmosphere that may arise from the influence of the motion of the earth. It carries an analog computer into which the latitude and longitude of the origin and target are inserted.

It starts dead-reckoning at launch and computes the instantaneous latitude and longitude continually, being corrected for drift and other random effects by an ingenious system of timers and accelerometers, and sometimes with an automatic star-tracking telescope system, which takes celestial fixes to correct the net reading of the computer.

Readings are taken by observing the apparent positions of selected stars in terms of imaginary lines between the stars and the center of the earth. Consulting an elementary text on celestial navigation will show this to be theoretically simple, but tricky in application. However, reliable automatic stellar navigation systems are in existence.

Inertial Guidance

Inertial guidance systems, strictly speaking, are not foreign to the cruise-type missiles, but are less critical there, perhaps, than in the ballistic missile. In the ballistic missile, however, the inertial guidance system is more or less on its own, and has an appalling task. It can be aided by radio command—under certain conditions—during parts of the trajectory.

Mathematical analysis of a ballistic trajectory reveals it to be equivalent to a portion of an astronomical orbit, most of which lies inside the globe of the earth, which is in the shape of a nominal ellipse, having the center of the earth as one of the foci; hence the significant kinship between the ICBM and a satellite-carrying research rocket.

Considering the trajectory of the missile as a portion of the ellipse, it becomes clear why it is influenced by the motions of the earth. The earth rotates on its polar axis, revolving about the sun, moving with the solar system in the rotation of our galaxy, and is subject to an axial wobble like a spinning top and perturbations of other heavenly bodies. All of this affects missile flight, but for practical purposes, only the rotation of the earth has a really important effect on the missile.

That is to say, it is affected chiefly by the rotation of the earth on its polar axis, and complicated by the fact that the earth is oblate and otherwise not symmetrical. Without getting into the fine details, it may be stated that the rotation of the earth counteracts gravity somewhat by centrifugal force, and in complex ways because of its oblateness and the fact that few, if any, ballistic shots are made in, or exactly parallel to, the equatorial plane in which this counteraction has its simplest effect.

Army

The Army features missiles fired from the surface of the earth. It has four surface-to-air missiles—the *Hawk* and *Nikes-Ajax, Hercules* and *Zeus.* Surface-to-surface missiles include the *Corporal, Jupiter, Redstone, Sergeant, Dart* and *Lacrosse,* all mentioned in alphabetical order, by mission, in Table II.

Hawk is the in-fighter of the surface-to-air missiles. It is made as a complete system by the Raytheon Manufacturing Corp.'s guided missile facility at Bedford, Mass. Having spe-

cial radar to handle ground clutter, it deals with targets to which *Nike* radar is blind.

Guidance is radio command. This delta-wing solid-propellant rocket measures 16 feet long by 14 inches in diameter. Fired from launchers holding three birds, it can pick one airplane from a formation 22 miles away. Development was started in 1955.

The *Nike* beam-riding family exhibits progressively greater range and performance in each guidance system. Developed by Bell Telephone Laboratories, the guidance systems show foresight in that each succeeding missile can be used with existing equipment with a minimum of modification to that equipment. *Nike-Ajax*, begun in 1950, is gyrostabilized, and has a slant range of 25 miles. It is 20 feet long, less booster, and is one foot in diameter.

Nike-Hercules, a larger missile, is about 25 feet long, two feet in diameter, has a more massive booster, a 50-mile range, GE fuzing, and an atomic warhead. The *Ajax* canard controls were replaced with delta wings, but in the departure from canard lost no maneuverability. Western Electric builds the *Nike-Hercules* guidance and control equipment at their Burlington and Winston-Salem, S.C. plants. Development was begun in 1953.

Finally, the *Nike-Zeus*, a still larger missile about which little is known, was begun in 1955, and is reported to be competing with the Air Force *Wizard* as an ICBM killer. If true, the acquisition radar sensitivity and resolution, and the general performance of the missile must be startling. Range may be 100 miles. It is rumored that Sperry Gyroscope may soon figure in some phase of the guidance-system production.

In surface-to-surface missiles, *Corporal* is a smallish missile of classical lines, conceived by JPL, which operates first by radio command and then with ballistic trajectory after burnout. It is being shipped in quantity to England, and features an intriguing array of ground-servicing equipment.

Guidance equipment for the bird is being manufactured by Gilfillan in Los Angeles. It is over 40 feet long, has a range of about 150 miles and can accommodate an atomic warhead. Fuzing is by GE.

Jupiter, the Army's IRBM, has a range of about 1500 miles. It competes with the Air Force *Thor* as America's IRBM and has enjoyed a higher box score of successful flights. Ford Instrument Co. and ABMA have figured in the development of the guidance system. Dimensions are about 58 feet long by nine feet in diameter. Pictures revealing its finless stubby configuration have been released.

Redstone, like *Jupiter*, is the concept of Wernher von Braun, technical director of the Army Ballistic Missile Agency in Huntsville, Ala. This missile has carbon vanes in the main engine (a V-2 hallmark), and fins for both stages. It has a range of about 200 miles and measures 60 feet long by 5.5 feet in diameter. Guidance is by Ford Instrument. Development was begun in 1952.

Little is known of *Sergeant*, except that it is probably a larger version of the *Corporal* and has a longer range. It is presumably guided by radio command during the early trajectory and exhibits ballistic behavior afterwards. It may be enough larger than *Corporal* to be a two-stage missile, in which case it may resemble the *Redstone* and have approximately the same range without being as large. If so, one may speculate on a length of 50 feet and a diameter of about four feet.

Dart, begun in 1955, is the smallest of the Army's missile arsenal, measuring five feet long by eight inches in diameter. The guidance system, developed by Wagner Electric Co. of Jersey City, is optical, and features control by thin wires unreeling from bobbins at the tips of two of the cruciform wings.

It is in production for use against tanks and pillboxes and is reminiscent of the larger German X-4 used from airplanes in World War II. Range could hardly exceed two miles, hence the use of optical guidance. It is very simple and cheap.

Lacrosse resembles the X-4 in size and shape much more than *Dart*. International Telephone and Telegraph did the entire computing, ground, air and tracking system. Cornell Aeronautical Laboratory developed the missile, which is now being manufactured at Martin's Orlando, Fla., plant.

Lacrosse, however, is a completely free-flying missile. It has command guidance and a range of eight miles. Fuzing is by GE. It is an all-weather weapon, which may carry tactical atomic warheads from truck launchers to smash fortifications. It measures approximately 14 feet long by one foot in diameter, and has a cruciform wingspread of over 10 feet, enabling a terminal gliding phase if desired. The Marines may use it.

Navy

Since the Navy has its own private air force, the variety of missile types is greater than that of the Army and closely parallels that of the Air Force, except for fewer types of surface-to-surface missiles plus the air-to-underwater missile possessed by no other service.

Names include *Talos*, *Tartar*, and *Terriers* I and II. Air-to-air missiles include the *Sidewinder* and a rasher of *Sparrows* rumored to number as high as IV or V. Air-to-surface missiles are represented by a single model, the *Bullpup*, which is rumored to have a big brother, the *Bulldog*, but no data on it has appeared.

The Navy's functionally unique air-to-underwater missile is *Petrel*. Vague kinship to *Bat*, *Grebe* and *Pelican* (actually air-to-surface missiles) is possible. Surface-to-surface missiles include *Polaris*, *Regulus* I and II, and *Triton*.

The missile *Talos* has an obscure and confusing background featuring a variety of propulsion systems using rockets and ramjets, perhaps together. The Navy's *Talos* is a surface-to-air missile. Another version was made for

Fig. 5—Communications console from the fire-control center of a TALOS unit.

the Air Force and then reportedly handed over to the Army and it is thought that a surface-to-surface model exists. Development was begun in 1953. The guidance system (ground components) was made by RCA. Airborne components were developed by IT&T.

It is apparently a rocket-boosted ramjet 10 feet long by 18 inches in diameter. It is a beam-rider with semi-active radar homing plus proximity fuze. Guidance antennas are arranged in an odd pattern of strips set into the "skin" and a prickly array of prongs extending forward and outward. Four are for guidance and the fifth is an angle-of-attack probe. Range is estimated to be between 50 and 70 miles.

Little is available on *Tartar* except that it is similar to *Terrier* and smaller—about 24 feet long by 10 inches in diameter—and may have a range of about 30 miles despite the fact it has no booster. It will go on cruisers and perhaps destroyers. Prime contractor is Convair.

Two *Terriers* exist but clear information is available only on *Terrier* I. It measures 27 feet, with booster, by 12 inches in diameter. It is a beam-rider with a range of at least 10 miles.

Both Convair missiles are solid-propellant rockets. The first had a guidance system by Reeves and the control system of the second is by Motorola, Inc. IT&T developed the airborne guidance equipment. *Terrier* II has a range of at least 20 miles and is also a beam-rider.

The *Sidewinder* may be regarded as the engineer's masterpiece. It is unbelievably simple, small, light, cheap and accurate—everything most missiles have gained a reputation for not being. It uses infrared homing based on a system invented by Dr. William B. McLean, technical director of NOTS, China Lake, Calif. McLean is said to have made the prototype on his own time and scored his first bullseye in January 1954, when it knocked down a QB-17 without a warhead!

The IR scanner gathers energy through a lenslike nose, focuses it on a detector which provides a signal for amplification and fin control. It is estimated to have saved the equivalent of nearly $50 million in comparison with similar missiles.

The *Sidewinder* is controlled by canard fins and can take 14 g's of turning acceleration. Nine feet long by 4.5 inches in diameter, it weighs only 155 pounds and has a range of about six miles. It has flown up the tailpipe of a jet drone (possibly a *Matador*) and gained fame by knocking a wingtip flare off another drone without destroying it.

Development of the guidance and control on an industrial basis is attributed to ACF, with guidance and control production both by Philco, the prime contractor, and GE.

The *Sparrow* family is based on a complete system originally developed by Sperry beginning about 1951. Douglas was prime contractor on *Sparrow* II and Raytheon on *Sparrow* III. Data on *Sparrows* IV and V is very vague. Douglas may have been the guidance contractor on *Sparrow* II.

Raytheon handles the complete system on *Sparrow* III, which is probably the production version replacing *Sparrow* I. It is rumored Raytheon will handle *Sparrow* V. All *Sparrows* appear to be beam-riders, and the later versions may not have boosters. It measures about 12 feet long, with booster, by six inches in diameter. Range is about seven miles.

Bullpup, the Navy's air-to-surface missile, is developed as a complete system by Martin and is made at the Orlando plant. It is command-guided, measures 11 feet long by 15 feet in diameter and is canard-controlled. Development began in 1955.

The *Bullpup* was the result of a 14-company contest for a missile to be used by attack aircraft against tanks, bridges and ships, but able to remain out of deadly ground fire by launching at medium distance and altitude. It was developed along philosophical lines similar to the *Sidewinder*, and features simplicity for fast development and maintenance. Range may be 20 miles.

Petrel is the subject of tight security despite long development time. It is thought to be a ram or turbojet which jettisons its propulsion system on striking the water, the remainder of the missile continuing on somewhat in the fashion of a torpedo against submarines. Range may be something like 20 miles, and guidance is likely to be radio command or a combination.

Polaris is the Navy's bid to get into the intermediate-range ballistic missile field. Development started in collaboration with *Jupiter*, and then the Navy withdrew on the grounds that liquid propellants were not suitable for shipboard use. This left the Army with a dynamic configuration about which they were probably not too keen, but with which they obtained excellent success anyway.

The advent of a solid-propellant rocket of this size was jolting news and a development which could conceivably foreshadow the end of liquid engines for IRBMs. Lockheed is the prime contractor, and General Electric has the contract for the development and production of the guidance system. Superprecision ocean navigation, the crux of a water-launched IRBM, has occupied the Navy during 1957.

Development was begun in 1955. Preliminary underwater tests of some kind have apparently already been made. Funding has suddenly been increased 200 per cent but the test shot is still probably two years away.

It appears that there will be a pod nearly 50 feet long which will enclose the rocket proper, measuring 30 feet in length by four feet in diameter. It is likely to be launched underwater from an atomic submarine either through the torpedo tubes, or, if there is enough vertical clearance, through the conning tower.

Regulus I was begun in 1951 by Chance Vought, possibly with Sperry guidance. Bell Aircraft is thought to have figured in the development of the reusable model which came home and landed, probably by remote landing system. The missile is designed for an atomic warhead and measures 33 feet long by 4.5 feet in diameter. Range is about 250 miles.

SOME REPORTED PRICES

NAME	Reported Cost Empty	Latest Definable Guidance Contract Total	To Whom
Atlas		$83,000,000	GE
Bomarc		$ 7,500,000[2]	Motorola
Dart	very low		
Falcon I	$24,000		
Falcon II	$ 9,000		
Jupiter		$ 9,500,000[2]	Motorola
Matador	$90,000		
Nike-Ajax	$20,000		
Regulus I		$ 3,500,000[2]	Motorola
Sidewinder	$ 800		
Sparrow I	$10,000	$30,000,000[4]	Sperry
Terrier I	$30,000	$11,500,000[5]	Motorola
Thor		$38,000,000[6]	AC Electronics

NOTES: [1] Guidance beacons and data link.
[2] Radio guidance only. Ford Instrument inertial guidance total probably greater.
[3] Guidance beacons.
[4] R&D, and early production.
[5] Complete electronics (BW-1).
[6] For R&D and some pilot production. Missile since ordered into full production. AC already tooled. Program is being substantially increased.

The guidance type has not been stated but may be single-axis inertial plus autopilot. Development on *Regulus* II began in 1954 to produce a model of increased range and speed. Guidance is by Sperry, at least the autopilot part of it. It measures 57 feet long by five feet in diameter and is probably now operational on submarines. Wing theme is canard, range 300 miles, and the use is reduction of heavily defended shore targets.

This missile is reported to have surprised most agencies that tested it. *Triton* is reported to be a sort of super-*Regulus* with a 1500-mile range. It may possibly carry a hydrogen warhead.

Air Force

Bomarc is a spectacular rocket-boosted, ramjet-powered surface-to-air missile of about 300 miles range. It is about 66 feet long, launched like a VTOL airplane and is distinguished by its diamond-shaped wings and underslung ramjet pods. Reports of the guidance type are conflicting, naming both beam-riding and command guidance. The latter is probably correct.

Terminal-phase active radar homing is also used. Development was begun in 1952. The guidance system is produced by Westinghouse. Certain components, possibly stable platforms, computers and gyro devices may be made for *Bomarc* by Lear, Inc.

Air-to-air missiles include two highly mysterious models known as *Ding-Dong* and *Genie*, about which it is known only that they carry nuclear warheads and are designed to destroy whole formations of bombers rather than one at a time.

Both *Falcons* are produced completely by Hughes Aircraft. *Falcon* I first flew about 1950, was radar-guided with a homing head (perhaps radar), measured six feet long by six inches in diameter and had a reported range of about five miles. Always fired in salvo, both *Falcon* models are often mixed with *Sidewinder* for a probable 90 per cent kill.

Development of *Falcon* II started about 1952. Actually it is an all-weather model, not in competition with the daylight *Sidewinder*. Using IR homing, it is 6.5 feet long by 6.5 inches in diameter.

The lone air-to-surface representative, *Rascal*, is a weapon system complex beyond man's wildest dream of artifact. A descendant of the *Shrike*, development began about 1950. It measures about 30 feet long by about four feet in diameter. Carried by a B-47 or B-52, it has a 100-mile range and climbs briskly to 85,000 feet after launch to avoid interception.

It is guided by radio command from the carrier aircraft which is by then scuttling back toward home base. Wing form is canard. Bell Aircraft is the prime contractor. IT&T is the subcontractor for guidance, and has recently undertaken a redesign of the control system.

Atlas is the pride and joy of the Air Force, and possibly the real hope of America as the ICBM, despite interesting rumors that the *Titan* is even better. If the reported length of 65 feet is correct, recently published photographs suggest a diameter of about 9.6 feet.

Development was begun in 1954 by Convair. General Electric received a guidance production contract of $83 million early in 1957, and developed an autonomous new group to handle it. Development has been proceeding on an overtime basis for about two years. Accuracy of the inertial-celestial guidance system is said to be 20 miles in 5000. If this is considered sufficient, the warhead must have a stupendous diameter of burst.

Fig. 6—Assembly production line for THOR inertial guidance components at AC Spark Plug. Recent THOR firings have used full inertial guidance.

Thor, the IRBM of the Air Force, had a discouraging beginning which nearly sealed its doom in the face of repeated successes by Army's *Jupiter*. It began to perform well in the latter half of 1957 and had a 1500-mile flight on September 20. The inertial guidance system is by MIT and the warhead by Sandia Corp. AC Spark Plug has the guidance production contract. *Thor* is a single-stage missile of roughly the same dimensions as *Jupiter*.

Titan is equal to *Atlas* in size and range, and is also inertially guided. Data on this missile has been particularly scarce. Martin, the developer, has combined *Titan* operations with those of *Vanguard* which may presage a jumbo-sized satellite carrier some day. American Bosch-Arma developed the inertial guidance system, and is apparently producing it. *Titan* is a two-stage missile, reportedly using many parts from *Atlas* and has a warhead by Sandia Corp.

Matador, a short-range cruise missile, was the Air Force's first venture into the surface-to-surface field. It was first tested about 1949. It has an approximate length of 29 feet (*Matador* II has a substantially longer nose), a span of 40 feet and a diameter of 54 inches.

A still newer *Matador* III may be the production version of *Matador* II. Quantities of *Matador* I have been sent to Europe, where they presumably carry nuclear warheads. Guidance probably has a combination of radio command and inertial guidance.

Navaho is a dual ramjet big brother to *Matador*. Development was begun in 1953. It carries a nuclear warhead, probably hydrogen for 5000 miles by inertial and celestial guidance. North American handled the whole system, for which the contract was cancelled, apparently in favor of emphasis on ballistic missiles.

Snark, a huge and spectacular cruise missile, is now in assembly line production at Northrop, which handles the whole system. The guidance system apparently combines radio command with inertial guidance and stellar navigation. It is 74 feet long by 4.5 feet in diameter and has a 42-foot span in sharply swept-back wings. The inertial guidance, *Mark* I, was built by Northrop. Range is 5000 miles and it probably carries a hydrogen warhead.★

how industry solved

The Air-bearing Gyro Stabilization Problem

by John P. Jagy

USING THE air-bearing gyro as an element in an inertial guidance system presents a specialized problem in servo design. During a ballistic missile R&D program, two methods of stabilization were investigated. The particular problem was the design of stabilization servo circuitry for the virtually frictionless air-bearing gyro.

The air bearings have a coefficient of friction that is approximately one ten-millionth that of an equivalent ball bearing. Random torques to the air bearing are very small and the air bearing provides a negligible coefficient of viscous friction between the inner gimbal and the supporting case.

Fig. 1 is an illustration of an air-bearing gyro manufactured by Ford Instrument Co. for the Army Ballistic Missile Agency. The gyro element is the rotor of a synchronous motor which is mounted in conventional ball bearings within the air-bearing cylinder. The air bearing is formed by a cylinder enclosed in a housing supplied by constant air pressure with a constant clearance between the cylinder and the housing. The only contacts between the cylinder and the housing are those made by the electrical supply conical pivot points, which are precisely located on the air-bearing axis so that any friction force operates at zero radius and results in zero torque about the air-bearing axis.

An inductive pickoff is mounted on the gyro to sense motion about the air-bearing axis and to provide an error signal to the servo loop. Fig. 1 shows the gyro mounted on a single-axis platform.

Before proceeding with a discussion of circuitry and components, a servo analysis of single-axis stabilization with an air-bearing gyro will be given.

The torque about the platform axis is sensed by the gyro and causes precession about the air-bearing axis as an angular velocity. A reaction torque equal and opposite to the applied torque is generated by the gyro and is numerically equal to the gyro angular momentum and the air-bearing angular velocity. This is the basic gyroscopic equation relating torque reaction and precession rates about axes that are both perpendicular to the spin axis of the gyro.

Any torques about the air-bearing axis will similarly cause precession about the stabilized axis.

It is convenient as a mathematical tool to treat the gyro cross-coupling equations as two separate independent entities although, in reality, the two effects cannot be disassociated from each other.

With this understanding, the simplified block diagram illustrated in Fig. 2 establishes the differential equations of motion of the stabilized platform.

Note that the schematic has been intentionally drawn similar to those

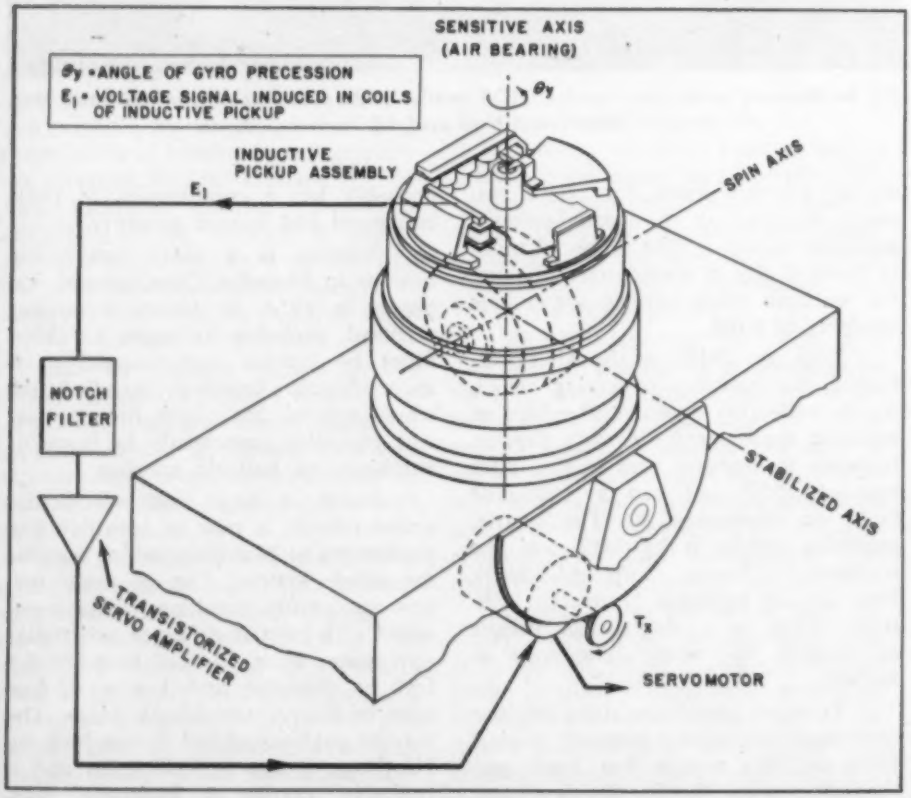


Fig. 1—Air-bearing gyro and stabilization circuitry on single-axis stabilized platform.

The author is project supervisor, missile development division, Ford Instrument Co., division of Sperry Rand Corp., Long Island City, N.Y.

frequently drawn by the servo engineer for a closed-loop feedback system and that the gyro cross-coupling terms are broken down and shown as two blocks.

Here in schematic form are expressed the differential equations of motion of this single degree-of-freedom platform with its air-bearing gyro. It is necessary to consider two rotational mass systems coupled by gyro torques and elastic restraints provided by the servo.

The inputs to the system to be considered are torques about the X and Y axes.

1) **T_u—torque applied to the gyro about the air-bearing axis.**

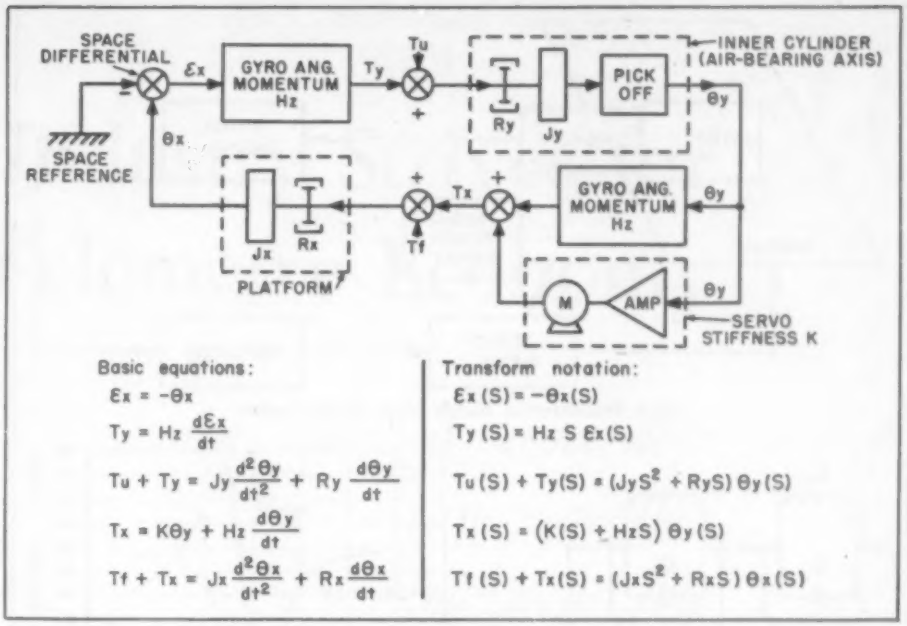
2) **T_f—torque applied to the platform about the stabilized axis.**

The basic equations interrelating all these quantities are shown in the lower part of Fig. 2. Here gyro torques and inertial reaction torques are equated. The fourth equation containing the servo stiffness factor K needs further interpretation.

In order to prevent precession of the air-bearing axis into its 90° position, which would render the gyro useless, the gyro torque is assisted by a torque produced by the servomotor. The air-bearing axis motion is sensed by an electromagnetic pickoff on the gyro. The pickoff signal is amplified by the servo amplifier and the amplified signal drives the motor to provide a torque. This torque assists the gyro in overcoming any friction or external torques about the gyro's stabilized axis. The servo stiffness factor K describes the electromechanical gain of the system having the same units as an equivalent torsional spring.

The five equations in Fig. 2 form the basis for the complete analysis and lead to the equations in Fig. 3.

This will be a stable dynamic system provided the servomotor is capable of supplying a torque to the platform that is proportional to the gyro pickoff error plus first and second derivatives of the error. This relationship is indicated in the last equation of Fig. 3. Without these error derivatives introduced into the servo system, the stabilized platform would be highly oscillatory following any disturbance since the damping of the air bearing is exceptionally small. The platform will oscillate at the natural frequency as determined by the third term in the denominator with $K_2 = 0$. The term $\frac{H_z^2}{J_x J_y}$ is the square of this natural frequency. If the error derivatives are not present, the allowable servo stiffness (K_1) must remain very low to prevent instability in the system. A high stiffness is desired to reduce the errors in gyro axis alignment in the presence of disturbance torques. The error derivatives are provided by incorporating a phase-lead network into the servo system.



Basic equations:

$$\varepsilon_x = -\theta_x$$

$$T_y = H_z \frac{d\varepsilon_x}{dt}$$

$$T_u + T_y = J_y \frac{d^2\theta_y}{dt^2} + R_y \frac{d\theta_y}{dt}$$

$$T_x = K\theta_y + H_z \frac{d\theta_y}{dt}$$

$$T_f + T_x = J_x \frac{d^2\theta_x}{dt^2} + R_x \frac{d\theta_x}{dt}$$

Transform notation:

$$\varepsilon_x(S) = -\theta_x(S)$$

$$T_y(S) = H_z S\, \varepsilon_x(S)$$

$$T_u(S) + T_y(S) = (J_y S^2 + R_y S)\, \theta_y(S)$$

$$T_x(S) = (K(S) + H_z S)\, \theta_y(S)$$

$$T_f(S) + T_x(S) = (J_x S^2 + R_x S)\, \theta_x(S)$$

Fig. 2—Functional schematic diagram and equations of motion of a single degree-of-freedom stabilized platform with an air-bearing gyro and stabilization servo circuitry.

$$\theta_x(S) = \begin{cases} \dfrac{1}{H_z S} \cdot \dfrac{\frac{K_3 H_z}{J_x J_y} S^2 + \left(\frac{(K_2 + H_z)H_z}{J_x J_y}\right) S + \frac{K_1 H_z}{J_x J_y}}{S^3 + \left(\frac{R_x}{J_x} + \frac{K_3 H_z}{J_x J_y}\right) S^2 + \left(\frac{(K_2 + H_z)H_z}{J_x J_y}\right) S + \frac{K_1 H_z}{J_x J_y}} \cdot T_u(S) \\ \dfrac{1}{J_x} \cdot \dfrac{S}{S^3 + \left(\frac{R_x}{J_x} + \frac{K_3 H_z}{J_x J_y}\right) S^2 + \left(\frac{(K_2 + H_z)H_z}{J_x J_y}\right) S + \frac{K_1 H_z}{J_x J_y}} \cdot T_f(S) \end{cases}$$

$$\theta_y(S) = \begin{cases} \dfrac{1}{J_y} \cdot \dfrac{S}{S^3 + \left(\frac{R_x}{J_x} + \frac{K_3 H_z}{J_x J_y}\right) S^2 + \left(\frac{(K_2 + H_z)H_z}{J_x J_y}\right) S + \frac{K_1 H_z}{J_x J_y}} \cdot T_u(S) \\ -\dfrac{1}{K_1} \cdot \dfrac{\frac{K_1 H_z}{J_x J_y}}{S^3 + \left(\frac{R_x}{J_x} + \frac{K_3 H_z}{J_x J_y}\right) S^2 + \left(\frac{(K_2 + H_z)H_z}{J_x J_y}\right) S + \frac{K_1 H_z}{J_x J_y}} \cdot T_f(S) \end{cases}$$

$$K(S) = K_1 + K_2 S + K_3 S^2$$

$$T_x(t) = K_1 \theta_y + K_2 \frac{d\theta_y}{dt} + K_3 \frac{d^2\theta_y}{dt^2}$$

WHERE:

H_z = Angular Momentum of the Gyro.

J_y = Moment of Inertia About Air-Bearing Axis.

J_x = Moment of Inertia of Platform About Stabilized Axis.

R_x = Damping Coefficient About Stabilized Axis.

K = Servo Stiffness Coefficient.

T_u = Torque Applied About Air-Bearing Axis.

T_f = Total Torque Applied About Stabilized Axis

S = Laplace Differential Operator $\frac{d}{dt}$

θ_y = Angular Displacement of the Air-Bearing Cylinder Measured with Respect to Inertial Space.

θ_x = Angular Displacement of the Platform Measured With Respect to Inertial Space.

Fig. 3—Closed-loop transform equations in one-axis stabilized platform with air-bearing gyro.

The steady-state solution to the equations is obtained by setting all derivatives equal to zero in the Laplace Transform Notation. This is accomplished by setting $S = 0$. If T_u is an applied constant torque then the platform will precess at a rate inversely proportional to the gyro angular momentum. Torque T_u must be kept equal to zero if a stable reference system is to be realized. This is the reason, then, for using the extremely low-friction air bearing for the sensitive axis. If T_f is an applied constant torque about the stabilized axis, then it is seen that the platform motion is identically zero in the steady state. The motion about the air-bearing-gyro axis θ_y is inversely proportional to the stiffness K_1 in the servo system. This points to the need for a high value of stiffness if rotation about the air-bearing axis is to be held to reasonably small angles in the presence of disturbing torques about the stabilized platform axis.

K_1 cannot be increased without bound, a fact evident when the transient response of the system is considered. The transient response is determined by the roots of the third-order denominator of the characteristic equation. There must be no roots with positive real parts or the system will be oscillatory. Positive values for the error derivative terms K_2 and K_3

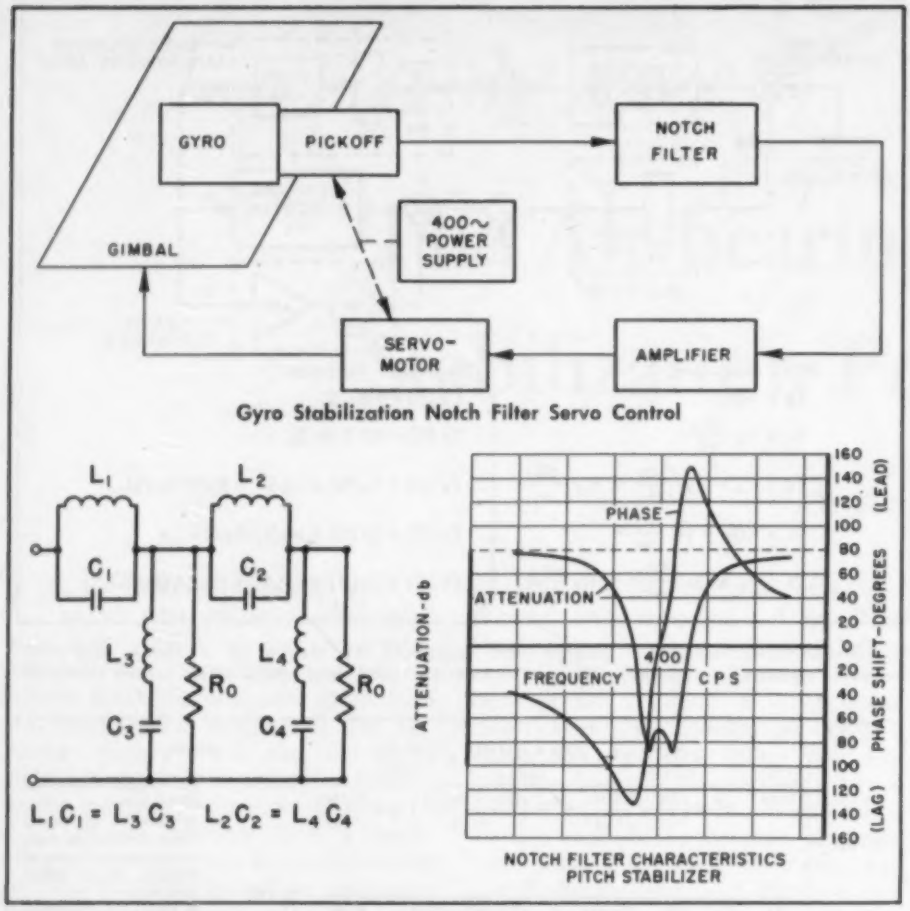


Fig. 4—Notch filter system block diagram schematic diagram and system characteristics.

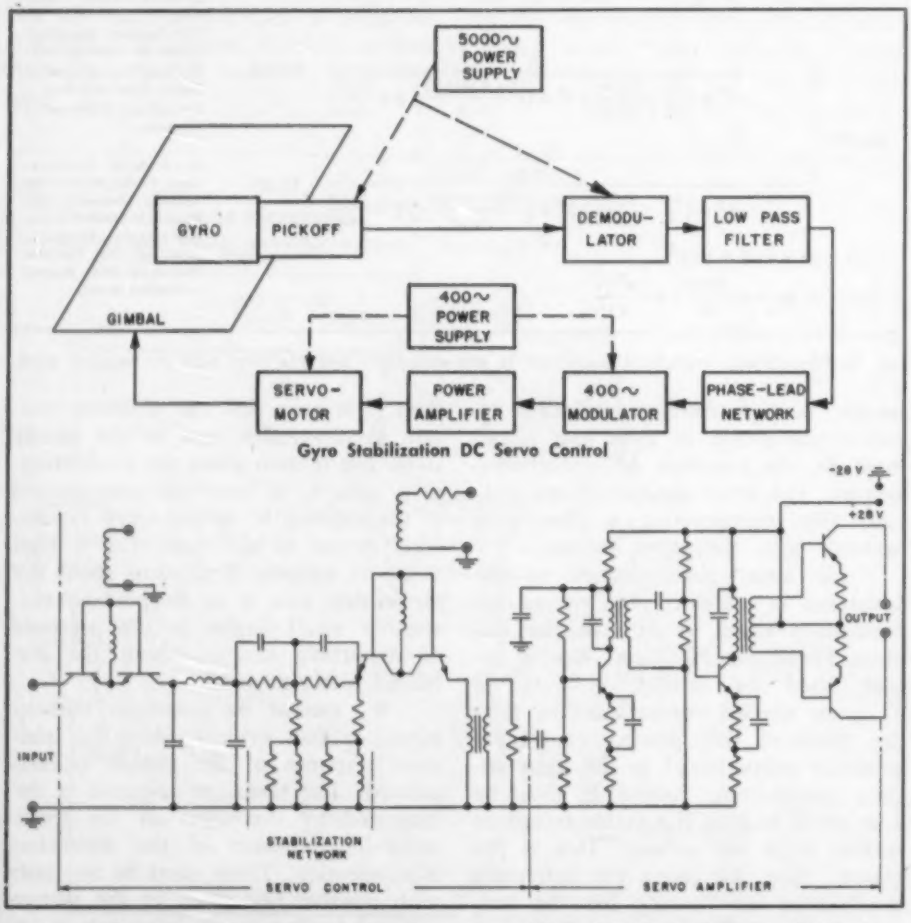


Fig. 5—Transistorized servo control and servo amplifier with block diagram of direct current stabilization servo control for a stabilized platform with air-bearing gyros.

are needed to meet this condition.

By substituting ja for S in the expression for K(s), the frequency response of the amplifier-motor-servo-system may be described. The gain of this servo must increase with frequency at a rate of 12db/octave and 180° of phase lead will be introduced in the limit.

Fig. 4 illustrates the circuit employed in the notch filter. It consists of a pair of constant K half-section band-elimination filters, stagger-tuned to give a W-shaped attenuation curve, as illustrated on the right. The attenuation and phase curves have their origin shifted to center about the 400-cycle carrier frequency. It is important that the phase peaks occur at the modulation sideband frequencies corresponding to the natural frequency of the stabilized platform.

The notch filter is the most critical element in the servo system because the components must be held precisely at calculated values.

The amplifier following the notch filter in the servo system consists of two high-gain, grounded-emitter stages —a push-pull driver stage and a push-pull power-amplifier stage. It is a traditional coupled type with reasonably flat frequency response in the vicinity of the 400 cycle carrier frequency. It has a wide range of gain so that the stiffness of the servo system can be set at the desired value.

The block diagram in Fig. 5 illustrates our alternate approach. In this arrangement the gyro pickoff is energized from a 5-kc source and the positional error signal is demodulated and filtered to remove the ripple. The high-frequency carrier is used so that filtering will not introduce phase lag into the servo system. The required phase lead is introduced by means of the phase lead network. The modified signal is modulated on a 400-cycle carrier and amplified to provide power to the servo-motor.

For the demodulator, a pair of transistors with their emitters in common has been used to provide high gain and proper impedance level between the pickoff and the phase-lead network.

In the 400-cycle modulator which follows, a pair of switching transistors with their collectors in common is employed to give the least noise in the output for zero signal.

Indications are that it will be possible to operate the servo loop at a higher value of stiffness and possible to lay out a smaller package.

It is intended that this alternate scheme replace the notch filter, thus removing the dependence upon absolute values of tuned elements.★

Industry Strives for Missile Telemetry Economy

miniaturized recoverable tape recorders now available

by John Kinkle

THE PRIMARY purpose of missile flight-testing is to obtain data under actual conditions of operation, but since data evaluation usually occurs some time after the data is obtained, the recording method used is critical to the reliability and accuracy of the flight tests themselves.

Most data-recording systems in use today use magnetic tape, either telemetered to a ground station or recorded directly with the use of airborne recorders. However, airborne recorders must be recovered undamaged. In missile and pilotless-aircraft testing, this has not always been practicable, unless parachute recovery of the vehicle is employed.

The MR-1 recorder, manufactured by Northam Electronics, Inc., Altadena, Calif., and shown in Fig. 1, was developed specifically for rocket flight-testing applications and contains a number of features not available in any other airborne recorder.

Overall size is four inches in diameter and five inches in length, complete with all accessories including batteries. Total weight is four and one-half pounds with armor and only two and one-quarter pounds without armor. As many as nine successful recoveries have been made with the same recorder.

As many as eight information channels are recorded simultaneously on one-half-inch, one-mil, mylar-backed magnetic recording tape.

Rugged construction, light weight and ability to operate satisfactorily under the most adverse environmental conditions make these recorders ideal for many missile and rocket flight tests. Satisfactory performance is obtained with accelerations up to 500 g's along the longitudinal axis and 250 g's transversely. Angular acceleration up to 200 radians/second/second and axial spin rates up to 3000 rpm do not affect performance.

Even values of twice these magnitudes will not damage the instrument permanently. Heavy armor protects the recorder and tape from extremely severe impact accelerations encountered when the missile or rocket under test falls to earth.

Storage temperatures in the range from –40°F to 150°F over a period of one week cause no deterioration of performance, and extremes of 700°F can be tolerated for periods up to two minutes. However, the operating temperature range is normally limited to 40°F-150°F, in order to assure reliable operation.

Conventional recording techniques are utilized for airborne recording systems. Direct recording is used where wideband or high-frequency information is desired; AM, FM, PDM, or PWM modulated systems are used for recording information from dc through low-frequency ac.

Northam has developed a new technique that permits a sharp increase in recording sensitivity with very simple accessory equipment. This consists of erasing a prerecorded saturation signal from the tape in proportion to the amplitude of the signal received from the transducer. After being erased, the amplitude of the residual signal is essentially a linear function proportional to the amplitude of the phenomena measured by the transducer. Carrier frequencies used to prerecord the tape are selected so that they are at least six times the highest frequency to be recorded. The major advantage of this system is that signal levels as low as 20 microwatts can be successfully recorded.

Fig. 1—MR-1 miniaturized tape recorder.

Any type of transducer instrumentation can be used with airborne magnetic tape recorders. The major types of transducers used and their application to airborne recording are:

Potentiometers. These operate directly into the recorder signal input.

Thermocouples. These may operate directly into recorder, provided low impedance recording heads are used

The author is associate technical director, Northam Electronics, Inc., Altadena, Calif.

to obtain correct impedance matching characteristics.

Strain Gauges. Bonded gauges do not deliver sufficient output to operate recorders unless operated in series-parallel combination to provide increased output. Unbonded gauges can be operated into the recorder when the impedance of the gauge is matched to that of the recording head.

Piezoelectric transducers. Output must be amplified before being fed to the recorder.

Variable reluctance transducers. These may be used when alternating current is available for excitation.

The above list contains only the major types in common use. However, other amplitude or frequency types could be used.

Critical components of any recording system are the recording heads. Sensitivity, noise level, frequency response and impedance are all factors critically affected by head design.

Since magnetic heads are inductive devices, the characteristics vary with frequency, length of air gap, laminations and coil windings. Spacing between adjacent recording elements of the head affect noise level and crosstalk. Tape speed across the head, and distance of the head from the tape seriously affect frequency response characteristics.

One critical area where response is impaired is the range in which the wavelength of the frequency being recorded approaches the gap spacing of the head. Other factors affecting frequency response are head alignment with respect to the magnetic tape, biasing voltages and thickness of the magnetic coating. Fig. 2 shows a typical frequency response curve obtained using heads with one-mil gap spacing.

Progress in the design of magnetic tape recording systems, more than any other factor, has enabled the art of data recording to advance as rapidly as it has. Continuous data flow is an essential requirement of present data-handling systems. Magnetic tape recordings, better than any other method, meet this requirement.

Typical Frequency Response Curve

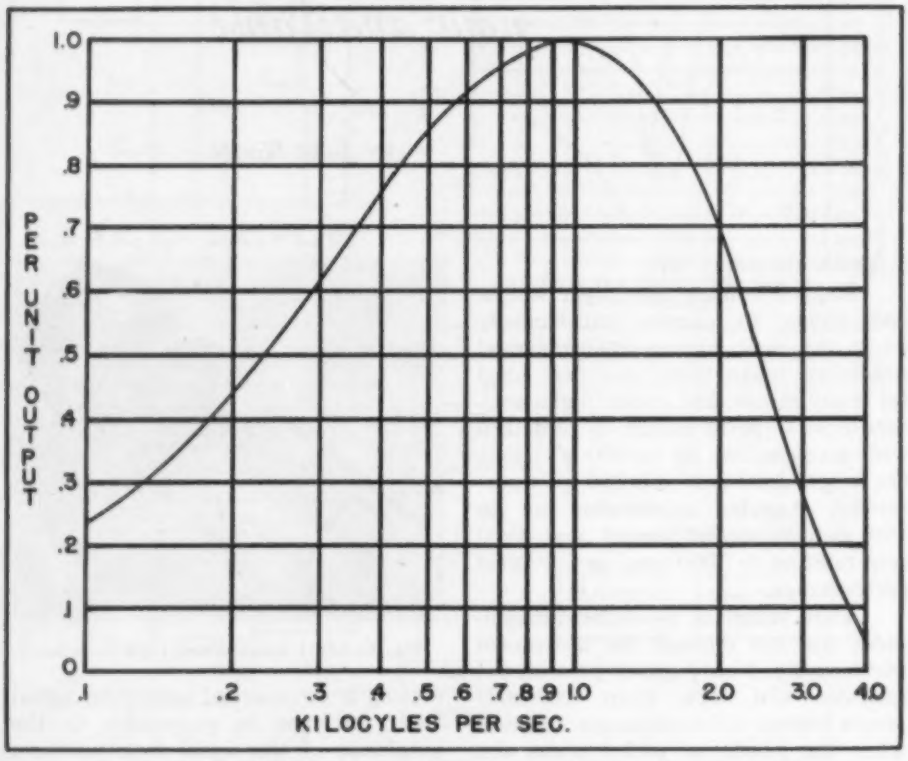


Fig. 2—Data obtained using recording heads with one-mil gap spacing.

As mentioned earlier, the Northam MR-1 recorder is a completely self-contained unit. In order to prepare the recorder for in-flight recording, it is necessary only to prerecord a saturation signal on seven of the eight information channels.

The eighth channel is used for the timing or reference trace, which is provided by a battery-powered transistor oscillator. Each data track is calibrated with 10 incremental values of current between zero and saturation. Standard recording speeds of 1 7/8, 3¾, 7½, and 15 inches per second are available and special units can supply tape speeds as high as 30 ips. Running time necessarily depends on capstan speed and tape length. The MR-1 operates two minutes at a tape speed of 3¾ ips, recording a total of eight channels.

Test missiles falling or driven to earth often bury themselves many feet deep in the desert sands. One recorder made nine such flights and in each case was recovered with only negligible or readily repairable damage. The tape itself was unharmed. Similar successes have been demonstrated with rockets and torpedoes.

Impact damage is confined to readily replaceable components, such as the battery case. The case is made of a crushable material to absorb impact shocks. Batteries, battery case, drive motor and electrical terminal board are considered expendable components.

The recorder and associated reel of tape are completely encased in a protective shell of heavy armor. Although the armor weighs only two and one-quarter pounds, it completely protects the tape. Thus, valuable information from the tests is immediately available for data reduction upon recovery of the recorder and associated tape.

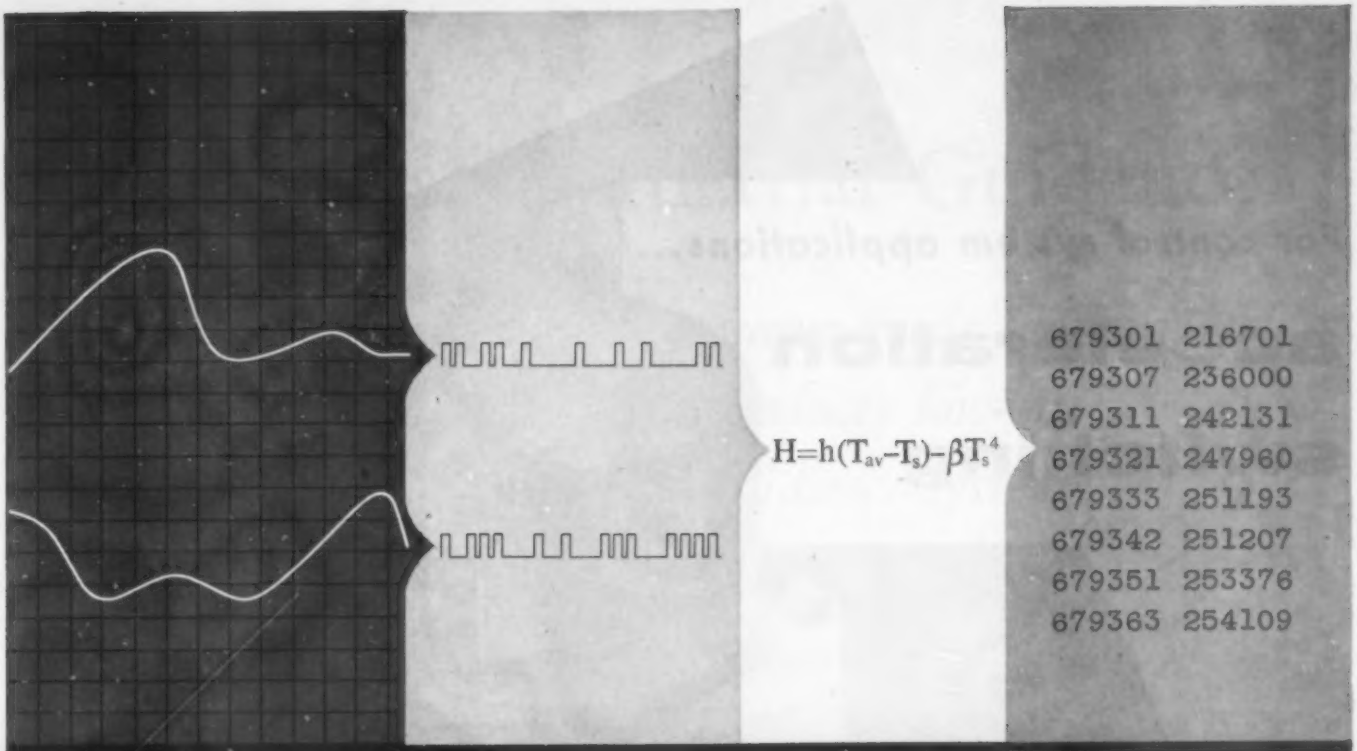
Evaluation of FM recording-system accuracy has consistently yielded results with an average system error of less than one per cent. Maximum system error is less than two per cent.

AM recording systems using the erasure technique yield results with a maximum error of five per cent. This higher value is due to the increased noise in the system, but is somewhat offset by the much simpler circuitry involved.

Comparison to telemetry data obtained from actual flight tests reveals similar results. While such a comparison is not a measure of accuracy as such, because neither system can be considered as a standard, the results are of interest. Continuous data obtained from on-board recorders provides measurements during periods when atmospheric ionization disrupts telemetering communications.

Noise in a system is important as a determinant of accuracy. Noise levels of FM in-flight recording systems have an RMS value of less than 1.5 per cent when used with a six-cycle filter. AM systems have a five per cent peak noise level over the range of zero to 250 cycles. Since low noise level and wide bandwidth or high frequency response are basically incompatible, some compromise must generally be made in order to obtain desired results.

The economies and reliability offered by this technique make it far superior, in some aspects, to any other method of obtaining test information. Automatic remote operations assure data acquisition during any desired portion of a specific flight-testing program, up to and including the moment of impact. ★



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Circle No. 13 on Subscriber Service Card.

Workhorse of Inertial Guidance

a consumer-goods company produces low-cost guidance systems

by Earl Finkle

THE LEV-3 GYRO Stabilizer was once described by Dr. Wernher von Braun, director of the Army Ballistic Missile Agency's development operations division, as "the workhorse of missilry." Certainly, this unassuming little device has contributed much to the current advance in inertial guidance systems for ballistic missiles.

The LEV-3 was originally designed and produced in Germany for the V-2 missile. When Dr. von Braun's development team and their equipment were brought to the United States after World War II, a substantial number of LEV-3s formed part of the hardware.

When the U.S. Army's high-altitude research program began at the White Sands Proving Ground, the V-2 missile with the LEV-3 as its stabilizer unit was used as the test vehicle. Repeated firings soon brought the number of stabilizer units to a low level, and the Army began a search for a competent manufacturer. Their choice was the Waste King Corp., manufacturer of household appliances, and active in the defense-products field since 1950. Using experience gained in various missile hardware programs, this company prepared a complete set of manufacturing drawings with specific design changes as a first step. From a much-modified sample built to these drawings, the drawings were again reworked and from these LEV-3s were placed in production. The stabilizer is still being delivered in sufficient quantities to meet the development program requirements of the U.S. Army.

The value of units such as the LEV-3 can be appreciated when it is realized that as inertial guidance has become more sophisticated, the cost of components for an inertial guidance system has soared.

These high unit prices mean that ballistic missile development is particularly costly during the full scale

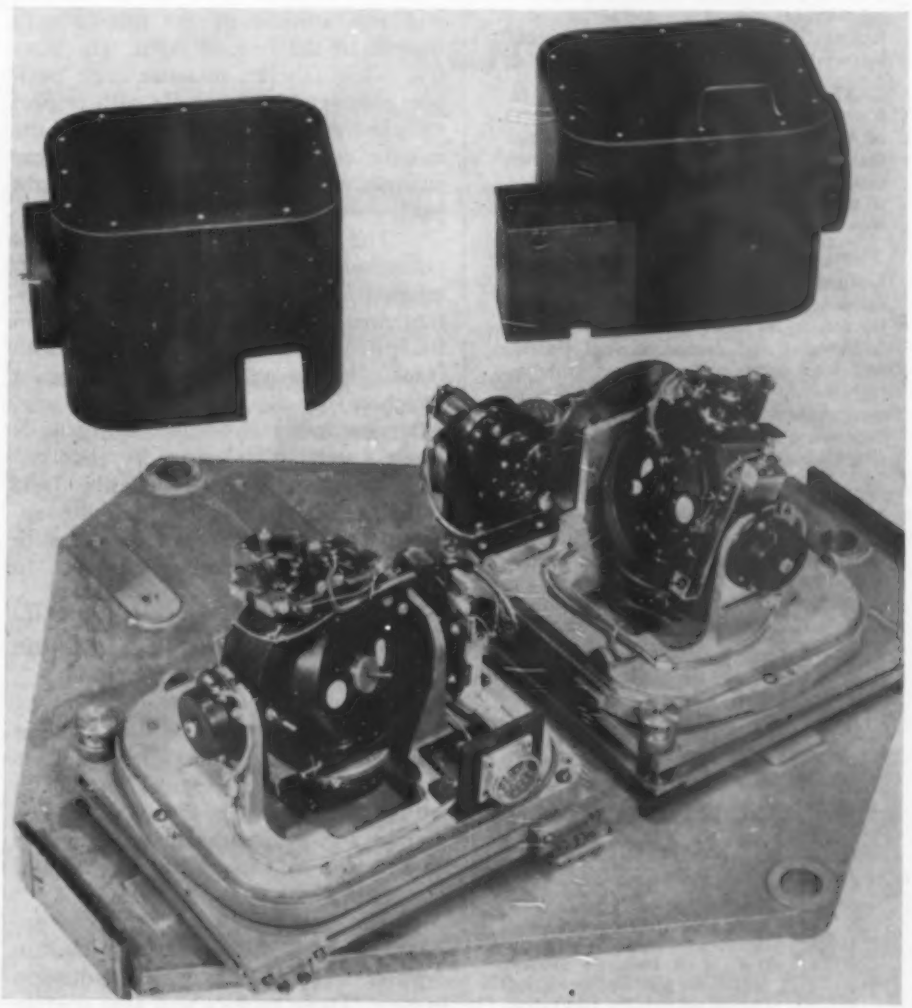

Fig. 1—Complete LEV-3 Stabilizer System with gyros and associated control circuitry.

The author is assigned to the technical products division, Waste King Corp., Los Angeles, Calif.

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flight-testing stage. It was in recognition of this that the Army Ballistic Missile Agency began to employ the LEV-3 stabilizer in its research and development firings, both as the primary guidance system and as part of the overall flight performance instrumentation. With the LEV-3, a means was at hand to provide satisfactory test guidance economically while performing engine and airframe testing.

At a cost order-of-magnitude substantially less than most ballistic missile inertial guidance systems, the reliability and accuracy of the LEV-3 has now been proved by more than 2000 successful firings. Operational and manufacturing "bugs" have been removed to the point where the guidance systems can be turned out on a full production basis.

A LEV-3 gyro system is shown in Fig. 1. It consists of two free gyros complete with gimbals, control potentiometers, current transfer assemblies, a program transmission, pendulums, torque motors and components parts necessary for mounting and adjusting. The unit on the left is the yaw-roll gyro; the unit on the right, the pitch gyro.

The yaw-roll gyro senses the yaw and roll attitude of the missile with respect to the line of flight. The control potentiometers measure these position changes of the missile with respect to the gyro element, enabling the missile controls to correct for these changes and maintain the desired flight path.

The pitch gyro with its control potentiometer and program transmission is shown in Fig. 2. The potentiometer, which measures changes in the pitch attitude of the missile with respect to the gyro element, is shown attached to the large-diameter gear. After becoming airborne the missile is given a specific trajectory by electrical pulses generated by the missile flight computer in conjunction with the appropriate accelerometers that measure the missile's altitude with respect to power cutoff.

These electrical pulses are fed into the program transmission shown on the extreme right hand side of Fig. 2, which causes the large gear containing the control potentiometer to rotate at a specific rate. This movement is measured by the potentiometer pickup which is attached to the position axis gimbal and causes the missile controls to alter the missile's pitch attitude and direct its flight path.

The gyro rotors are driven at approximately 22,000 rpm by built-in 3-phase 32-volt/400-cycle induction motors. These motors will also operate on 3-phase, 42-volt/500-cycle power, which was the power employed in the original V-2 missile. The rotor rpm at the 42-volt/500-cycle power is 27,000. The gyro motors, when running, draw 0.4 amperes per phase.

The other electrically operated components, such as the erection motors, potentiometers, etc., utilize 24-30 volts dc power obtained from sources in the missile control system. The program transmission requires 115 volts ac, 400 cycles, 1-3 phase continuously and is pulsed with 24-30 volt dc power.

Each gyro contains erecting mechanisms which keep the gyro from drifting when running for several hours during missile checkout. In general, a small pendulum senses changes in the vertical plane and a centering contact strip senses changes in the horizontal plane. Specifically, the pitch gyro employs a centering strip and pendulum.

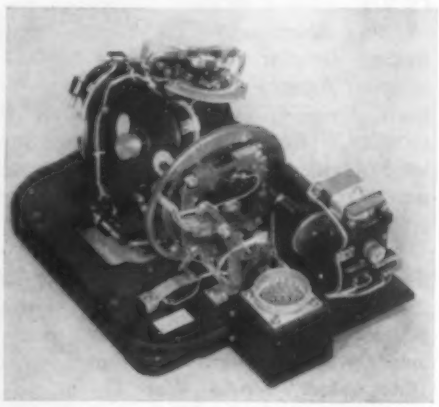


Fig. 2—Pitch-control gyro and circuitry which is pulsed in flight to alter missile pitch.

The yaw-roll gyro erects by means of a pendulum and a polarized relay external to the gyro energized by the roll potentiometer.

These sensing elements activate torque devices mounted on the principal gyro axes, causing counteracting precession to take place to correct the drift.

The control potentiometers are precision wound with .002-inch diameter, high-noble-metal content wire, with no spacing between turns. The deviation from linearity of these coils is less than one per cent. The diameter of the wire limits the resolution of the potentiometer to approximately seven minutes. The sliding pickup is formed from .002-inch diameter, high-gold-content alloy wire.

Accelerations experienced in the V-2 were 5 to 6 g and vibrations in the order of 100 to 200 cycles per second. Recent units with an optimum balance have withstood accelerations up to 12 to 14 g, as well as random

vibrations up to 1500 cycles per second.

The position axis of each gyro is most affected by g loading and missile vibrations. Friction induced into the gimbal axis bearings by these environments and reaction torques, which result when the potentiometer pickoffs "wipe" the potentiometers, contributes to normal drift rates of production units.

The Army Ballistic Missile Agency considers a drift rate of 10 minutes of arc per minute to be more normal for production units. Under very special conditions of balance, axis alignment and bearing selection, drift rates as low as .3 minute of arc per minute have been achieved.

The dimensions of each gyro with its cover in place are 10" x 8" x 8". A complete yaw-roll assembly weighs 8.25 pounds; a complete pitch assembly, 10.25 pounds.

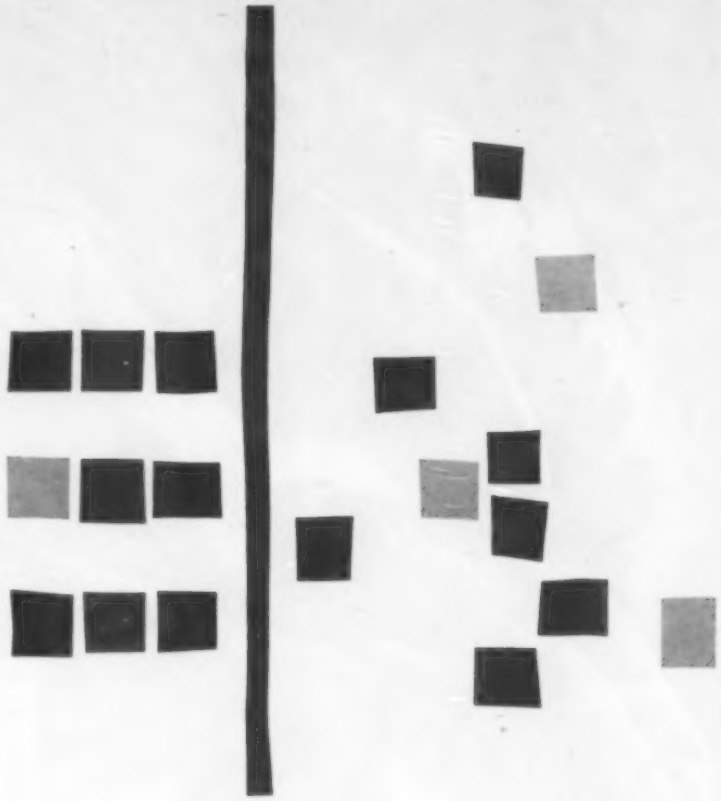
Each LEV-3 stabilizer is completely assembled and tested prior to delivery to the ABMA. Final calibration of the stabilizer prior to each particular missile firing is accomplished by ABMA technicians.

The inertial guidance equipment described in the foregoing paragraphs is a good example of the support that can be given the ballistic missile program by a company whose skills in commercial mass production are channelled into quantity production of intricate and high-precision mechanisms. This is not only good business for the companies concerned, but for the defense services. To them it means quick availability of units at a surprisingly low cost.

Waste King's decision to expand from automatic garbage disposers, dishwashers, ovens and home incinerators to complex guidance and rocket propulsion system components was a difficult one, representative of those decisions that must be faced almost daily if small business is to help provide the necessary technical support to the complex missile program.

An indication of the rewards of success in endeavors such as this is that this company's net sales have increased from $1,537 million in 1950 to an estimated $18 million in 1958.

This transfer of manufacturing know-how and technology has been concentrated by Waste King into its technical products division and has been successfully used on a wide variety of products. Evolution of the technical products division from a series of isolated operations, each meeting a specific need, is typical of the pattern shown by smaller consumer-goods manufacturers venturing into the defense program.★



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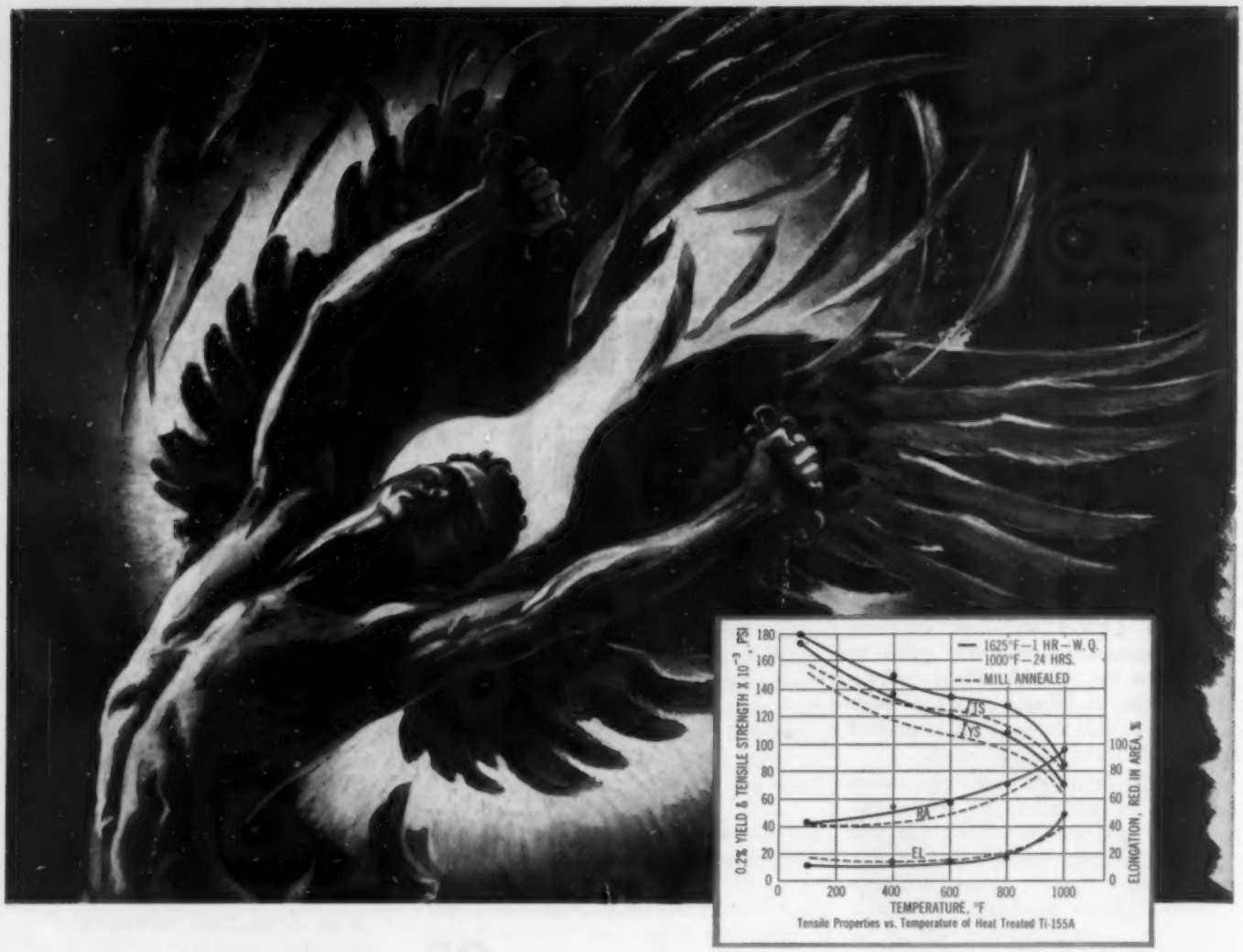

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Industry's Answer to the Data-processing Challenge

report on a flexible missile computer facility

by H. H. Rosen

EARLY IN 1956, intensive studies by the General Electric missile and ordnance systems department pointed to huge requirements for handling data and for performing computations at extremely rapid rates in the program to develop nose cones for the U.S. Air Force intermediate-range and intercontinental ballistic missiles.

It was also determined that, to be effective in the development, considerable data processing and computational capabilities would have to be made available in about 12 months. Further studies to reduce the initial data-processing and computation service requests to achievable dimensions resulted in the following design criteria for the system:

—Telemeter data input would arrive in the form of magnetic tapes.

—Fourteen continuous FM/FM data channels would be required.

—Ninety PWM/FM/FM data channels would be required.

—One hundred and fifty PAM/FM/FM data channels would be required.

—Low- and high-frequency vibration spectrum analysis would be required, in discrete bands.

—Equipment should be made as flexible as possible to accommodate readily to changes in the airborne instrumentation system and to meet other data-processing requirements that were necessarily not defined.

—The data system's accuracy should limit the degradation of data to not more than 1.5 per cent.

The author is manager of the data-processing and computation operation, missile and ordnance systems department, General Electric Co.

Definitions

DATA PROCESSING. The technique which uses men and machines to proceed automatically from raw test data to the final answer (the answer, however idealistic, being sought by means of the tests which yielded the data).

DATA CONVERSION. The manipulation of data into more usable forms, e.g., the changing of magnetic signals recorded on tape to electrical signals, and, in turn, to graphic presentations.

CONTINUOUS FM/FM TELEMETER. Transmitting data from a remote object by means of a radio line. The quantities to be measured are converted to electrical signals which deviate the frequency of subcarrier oscillators. The various subcarrier oscillators, in turn, frequency-modulate an RF carrier.

PAM/FM/FM. Several functions to be measured are converted to electrical signals which are then successively sampled in such a manner that each function is proportionate to the amplitude of a pulse. The successive pulses then modulate a subcarrier oscillator in the same manner as described above.

PWM/FM/FM. This system is similar to the PAM/FM/FM except that the value of the functions to be measured is related to the width of each pulse.

TIME-SHARED FM/FM. This modulation scheme, while containing vague similarities to PAM, is fundamentally different. In time-shared FM/FM, a subcarrier is frequency-modulated by long-time amplitude samples of several inputs taken in some regular sequence. Within a given sample, true instantaneous amplitude structure is preserved for later analysis.

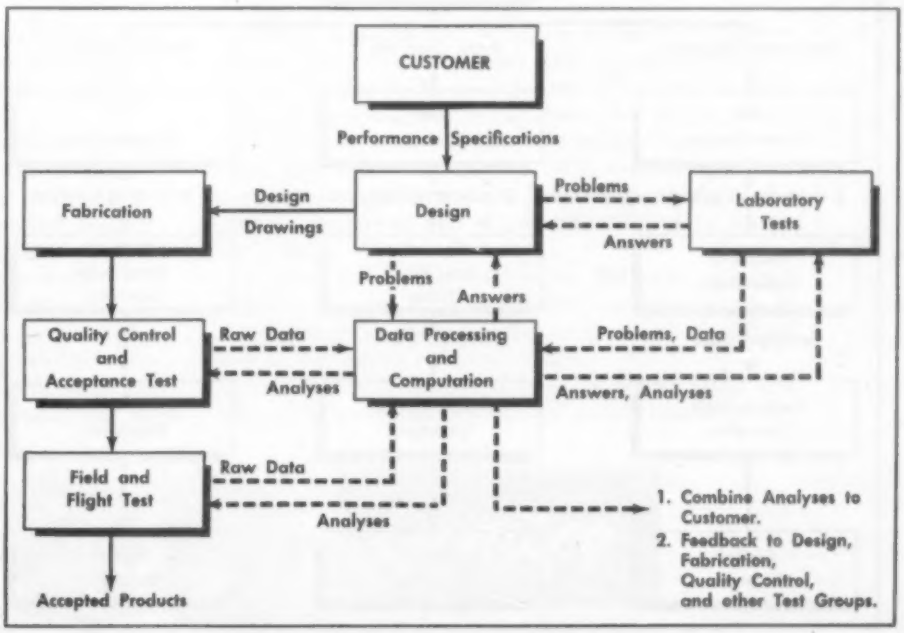

Fig. 1—Simplified diagram of product flow through data-processing center.

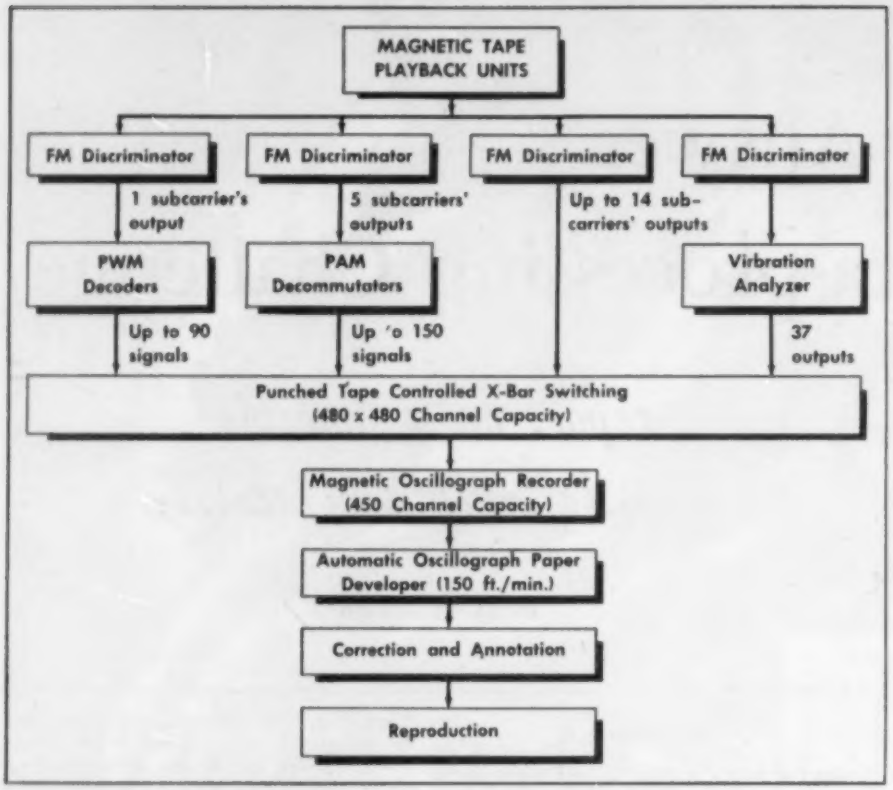

Fig. 2—Analog conversion system from magnetic tape to presentation.

—A limited facility for handling film, tabular and oscillographic data should be provided.

—Analog data should be handled independently of digital data.

—A large-scale computer of the Univac-Scientific or IBM 704-type would be required.

—The reduction and basic analysis of data from flight tests should be accomplished in 72 hours. The short period allotted to this function made it mandatory that major portions of the required analysis be predetermined and that the related computer programming be completed long before flight tests would take place. Similarly, the handling, correcting, annotating and presentation of data should be as routine and mechanized as possible.

—Time being vital, refinements should not be excessive and as many "off-the-shelf" items as possible should be used.

—Automation techniques should be used whenever their use is justified by savings in operating expenses, to meet schedules or to maintain required accuracies.

—A centralized source of technical data should be established to provide a rapid and effective means to use the data in numerous applications usually associated with missile development programs, such as missile history logs, reliability programs, logistics, automatic print control systems, failure reporting and analysis, etc. To provide this capability, a system for handling large quantities of data for filing, sorting and compiling would have to be designed. (It is this aspect of the criteria which, perhaps more than any other, gave meaning to the "integrated" concept of data processing that these criteria imply.)

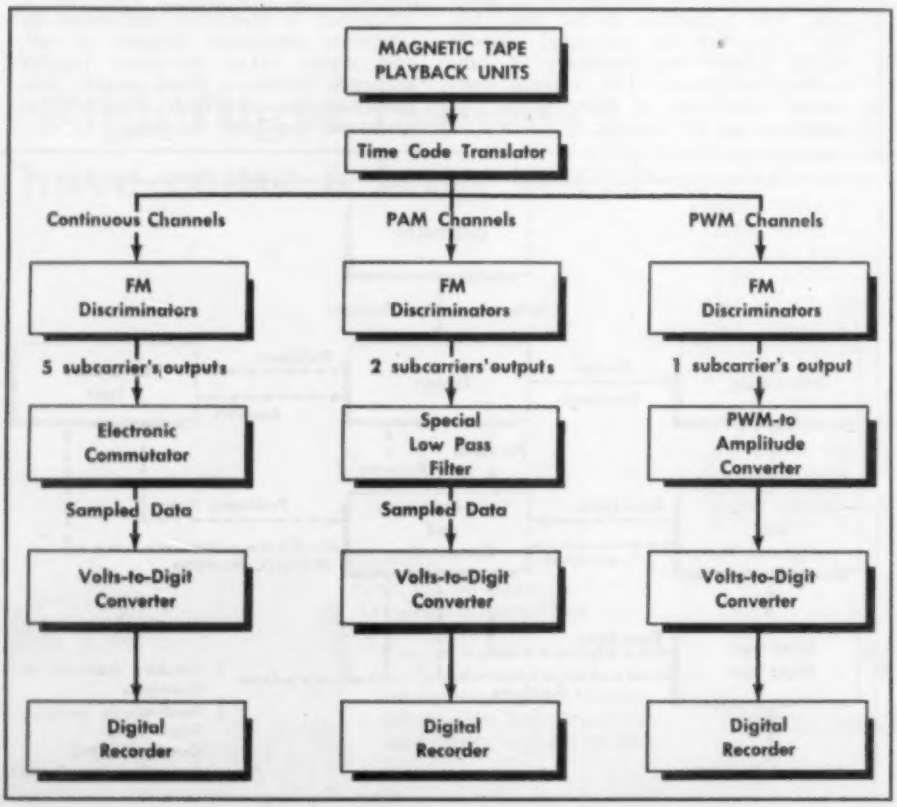

Fig. 3—Simplified block diagram of analog-to-digital conversion system.

Fig. 1 is an overall flow chart of the part the integrated facility plays in the two missile development programs. The flow of information starts with the customer's statement of requirements and ends when a tested and acceptable end item is ready for manufacture.

Inputs are of three types—magnetic tapes containing telemetered data; engineering and scientific problems; and punched cards, metric film, tabulations and oscillograms. The first of these three inputs—magnetic tapes—is handled in both analog and digital forms; the engineering and scientific problems by a computing facility; and the miscellaneous inputs of the third category by semiautomatic equipment.

The computing facility has two problems to consider here—magnetic tapes for conversion to corrected and annotated plots in a visible form; and magnetic tapes for conversion from analog to digital data for input to the computer.

The analog conversion system is depicted in Fig. 2. The playback units convert data on tapes to electrical signals for further processing. They handle ¼" 4-track, ½" 7-track, and 1" 14-track tapes and convert FM/FM

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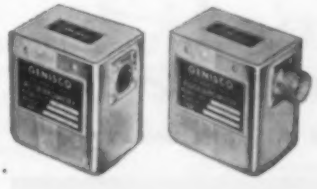

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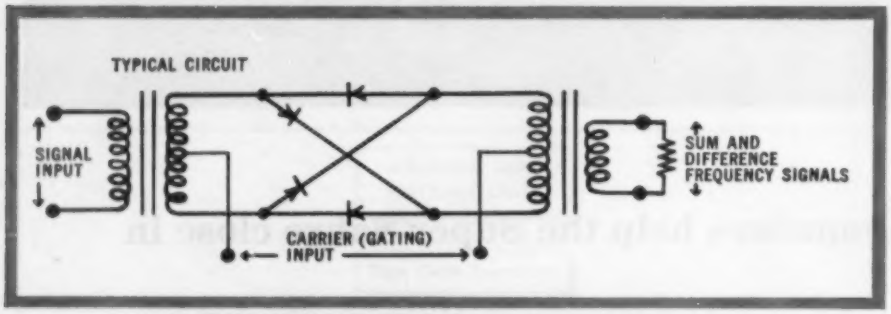

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SIGNAL SOURCE IMPEDANCE: 1000 ohms
SIGNAL INPUT VOLTAGE: 45 volts P-P maximum
SIGNAL INPUT FREQUENCY: 1300 cps
GATING SOURCE IMPEDANCE: 400 ohms
GATING SOURCE VOLTAGE:
Square Wave + 18 to — 18 volts P-P
GATING SIGNAL FREQUENCY: Square Wave, 650 cps
OUTPUT LEVEL: 0.25 to 2.0 volts P P
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continuous, PWM/FM/FM and vibration FM/FM data with speed lock compensation for wow and flutter. The subsystem can also handle 14 channels of directly recorded data by means of wide band FM techniques.

The PWM/FM decoder subsystem detects the subcarriers containing pulse-width data, converts each pulse-width signal to amplitude variation and presents up to 90 functions as separate amplitude-varying voltages. In addition to handling all standard IRIG (inter-range instrumentation group) PWM configurations, the system is compatible with data rates of 45 samples per frame at 2½ frames/second and 90 samples per frame at 5 frames/second. Deviations from scale-end points and drift are within 0.5 per cent of full scale and tape speed compensation is included to correct for wow and flutter effects.

The PAM/FM decommutation subsystem detects the subcarriers containing pulse amplitude data, separates (decommutates) each pulse, and forms a continuous voltage output for each measured function. One hundred and fifty channels of IRIG PAM data may

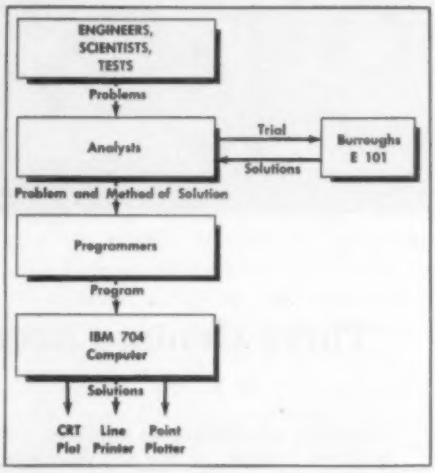

Fig. 4—Data flow in a computing system.

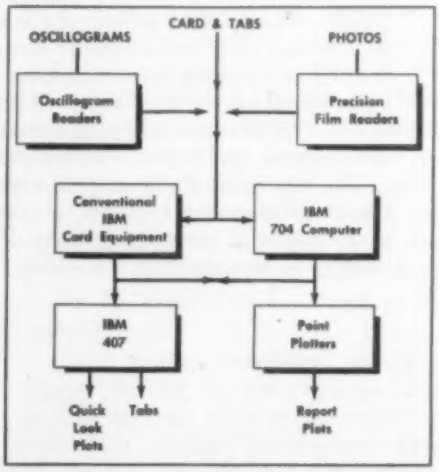

Fig. 5—Semiautomatic data handling system.

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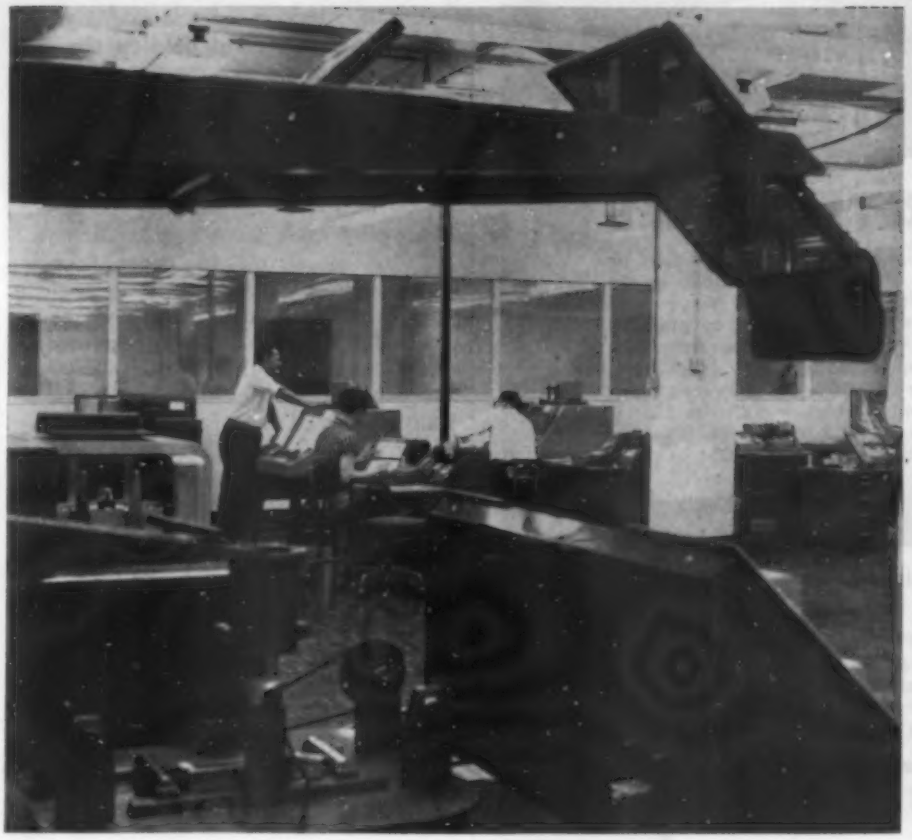

Fig. 6—One of five pulse amplitude modulation decommutation stations.

be handled simultaneously with output linearity of 0.1 per cent of bandwidth.

Here again, tape speed compensation is included to correct for wow and flutter. Noise is less than 0.1 per cent; drift is less than 0.5 per cent in 16 hours. Fifty per cent amplitude in subcarriers will result in less than one per cent change in pulse amplitude. (All percentages quoted are in per cent of bandwidth.)

The basic function of the continuous FM subsystem is to detect each continuous FM subcarrier and to present accurately-varying voltages which are analogs of measured functions. Among its features are an automatic five-point calibrator, troubleshooting panels and tape speed compensation. The subsystem is capable of handling up to 14 IRIG subcarriers simultaneously with output accuracy of 0.1 per cent of full scale and with output drift of less than 0.5 per cent in a 15-hour period.

The input signals to the vibration analyzer subsystem are either data from FM telemeter magnetic tape or from wide-band magnetic tapes. The subsystem is capable of decommutating the time-shared vibration data into individual complex waves and then presenting voltages proportional to g^2 (power) for discrete frequency bands —20-200 cps in bandwidths of 10 cycles each, and 100-2000 cps in bandwidths of 100 cycles each.

The cross-bar switching subsystem provides the capability to automatically switch any of the voltage inputs from the four previously described conversion subsystems to any part of the recording subsystem. The cross-bar subsystem is capable of handling up to 480 voltage inputs and is controlled by means of a seven-hole punched paper tape and/or keyboard. Crosstalk at 5000 cycles is −60 db and signal attenuation at 10 volts is 1:1000. A complete input-output configuration can be set up in seven minutes.

The input elements of the magnetic oscillograph precision recorder subsystem consist of 450 amplifiers with response to 2100 cps. Linearity and stability of the amplifiers are plus or minus 0.25 per cent obtained by a unique chopper technique using magnetic modulators.

Scale factor and zero offset corrections are set automatically by push-button control in 256 equal steps. Provisions have been made for later additions of punched-card or punched-tape control of these corrections. Each corrected output is applied to galvanometers of 30 Midwestern Model 591 oscillographs, each of which contains 15 active galvanometers. Thus, the output of the system consists of up to 30 rolls of exposed oscillograph paper (run at speeds from 0.4 to 129"/second), each containing up to 15 traces of information.

(*Continued on Page 100*)

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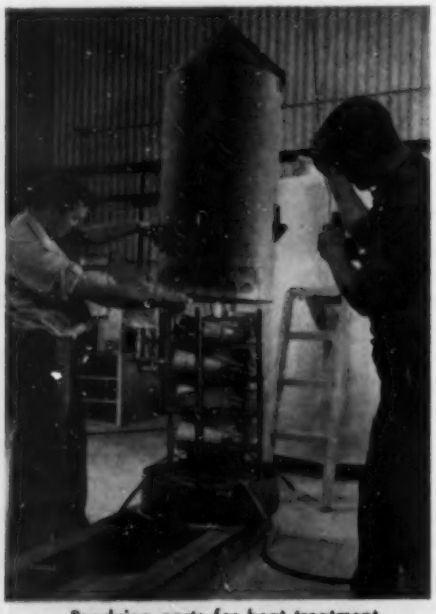
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The function of the oscillogram photo processor is to develop the exposed photographic paper obtained from magnetic oscillographs. This equipment is the first of its kind and has several unique features.

In brief, the roll of paper is inserted into the machine and the entire processing cycle from dry exposed paper to dry developed paper accomplished automatically at rates up to 150 fpm. The developing, fixing and washing is done at the high temperature of 180°F and only the emulsion side of the paper is wetted. As a result, essentially archival records with negligible distortions are produced.

The basic elements of the analog-to-digital conversion system are shown in Fig. 3. The prime function of this system is to convert all IRIG telemeter data recorded on magnetic tape to digital tapes compatible with IBM 704 computer equipment.

The system consists essentially of three types of subsystems to handle FM continuous, PAM/FM and PWM/FM telemetered data. The system does not decommutate, correct or scale the data because these operations can be performed more economically in the computer as part of a computation program.

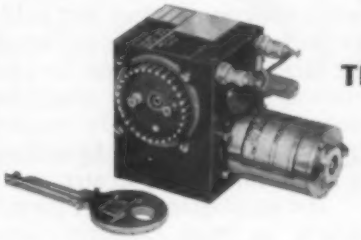
Each subsystem is independently operated and the accuracy is better than 0.5 per cent from analog tape to digital tape. The capacity of the system is about two million data points per hour. The function and capability of the magnetic tape playback is essentially the same as those units described previously as part of the analog conversion system.

The time code translator interprets the recorded test range time code and generates start and stop signals in accordance with preset switches which indicate the desired start and stop times. In addition, a 10-bit second code and a 10-bit millisecond code are made available to the digital recording unit for eventual recording on magnetic tape. The unit also provides internal time code in the event of absence or failure of recorded range time.

The FM discriminator units permit the selection of IRIG subcarrier channels. The continuous analog-digital conversion subsystem can handle any five of the 18 IRIG bands simultaneously.

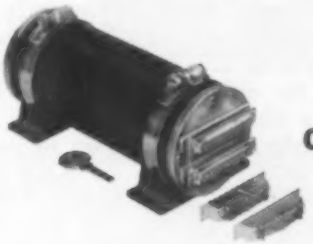
In the case of the PAM subsystem, any one of the IRIG bands from 10 through 18 may be selected whereas the PWM subsystem handles bands 18 and E only. The reason for these limitations is that lower bands cannot be used for PAM or PWM purposes. In addition to converting the FM data to analog voltages, these discriminators provide correction obtained

Time Division Multiplexers by ASCOP



TELEMETERING SENSOR SAMPLER

Type A: Sub-miniature 2 pole, 30 contacts per pole switch provides 60 channels in make-before-break operation. A filtered 27.5 volt DC motor rotates the switch at 2.5 RPS providing a sampling rate of 150 samples per second. Solid block construction permits satisfactory operation under random noise vibration of from 36 to 2000 cycles at 18 G's RMS, 160 G's impact for 2 milliseconds and a steady state acceleration of 100 G's.



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Type AS: The ASCOP Type AS multi-channel rotary sampling switch is designed specifically for airborne telemetering applications where precision high-speed sampling with the utmost reliability is necessary for accurate data. 3 poles 27 channels @ 2.5, 5 or 10 rps. 27.5 VDC governed drive. Proven reliability in 25,000 hours of life testing.

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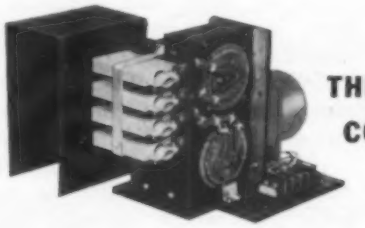
Type AN: This multichannel sampling switch is designed for use in a target designation system for fighter aircraft. The metal on metal hermetically sealed switch housing provides a dust-proof, moisture-proof, explosion proof enclosure to allow the switch to run properly at high altitudes over extreme temperature ranges.

INDUSTRIAL MULTIPLEXER

Type AU: This multipole sampling switch has been designed for the flexibility of application, ease of servicing and long life required for automation and control applications in industry. Speeds from 1 to 1800 RPM, 30 to 250 channels per pole, 1 to 20 poles. Years of service free operation.



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Type Y: Samples 40 independent low level sensors with a noise level below 20 microvolts. By reducing noise and leakage to a minimum, temperature variations smaller than 1°F can be detected when sampling copper-constantan thermocouples.

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from wow and flutter compensation signals on the telemeter tapes.

The electronic commutator samples each of the five continuous functions available from the discriminators in such a manner as to present sample data of each channel in cyclic fashion. Synchronized pulses for this purpose are obtained from an internal oscillator. The electronic commutator provides variable and fixed sampling rates from 100 cycles/second to 10,000 cycles/second. In addition, this unit provides an optional means by which the number of samples per digital record block may be selected.

The volts-to-digit converter accepts the sampled data from the electronic commutator, the low-pass filter or the PWM-to-amplitude converter, depending on the subsystem involved. The amplitudes of each sample are converted to parallel data codes for recording by the digital recording units. Besides the binary coded data values, the output includes codes for bad data, data present, time, time code present and frame synchronization.

The major function of the digital recorder units is to accept synchronous data codes and time codes in prescribed but variable formats compatible with IBM 700-series equipment. Each record group may contain fixes values which have been inserted manually, a record number for each block, time values for each block and up to 64 data words (12 binary bits/word) for IBM or up to 128 data words for other formats. Two buffer memories, one accumulating data while the other records on tape, permit the "real time" conversion of data at speeds slaved to the selected input data.

The special low-pass filter used with PAM/FM data eliminates spurious high frequencies present in the pulse train. The pass band is adjusted to make the best compromise between noise and sacrifice of rise time.

The function of the PWM-to-amplitude converter is to convert the train of pulse-width signals to a pulse amplitude train acceptable by the volts-to-digital converter.

The second of the inputs considered originates as a result of investigations, design and test activities as illustrated in Fig. 4. The analysts (physicists, engineers and mathematicians) work with the customer in formulating the problem as well as providing methods of solution. Two Burroughs E 101 computers are used for "one-shot" problems requiring comparatively short solutions.

The primary use of the E 101, however, is for trial solutions by the analysts. This provides the assurance that the methods of solution turned over to the programmers will work. Since the operational and design characteristics of the E 101 and the IBM 704 have been described elsewhere, no detailed description is given here.

The final category of inputs considered here exist because, while it is an accepted fact that magnetic tape is the best available medium for recording date to be handled by the facility, many laboratory, factory and field test sites are not equipped to record all of their data on magnetic tape. To provide a means for handling miscellaneous data, a limited capability (shown in Fig. 5) is available at the Data Processing and Computation Center.

The oscillogram readers permit the operator to read graphical data on oscillograms (up to 12″ paper and 16mm and 35mm film) by centering cross hairs on the point to be read; the output is in the form of automatically punched IBM cards. The facility can read about 14,000 points per day with these machines with a resolution of 0.003 inch.

The precision film comparator is capable of handling photographic plates and film from 16mm to five inches. Angular x and y measurements are made by the operator centering cross hairs on the point of interest (e.g., x and y) or along the line of interest (for angles). The output is in the form of automatically punched IBM cards on which are included the readings, frame count and other preset data. The capacity and resolution of the machine are 1000 frames per day and 0.004 inch, respectively.

The conventional IBM card equipment at the facility includes the normal array of IBM card-handling equipment, including key punches, summary punches, verifier, 407 tabulator used as a plotter for "quick look" presentations, reproducer, sorter, document originator, etc.

The point plotters convert data punched on IBM cards to point-by-point plots which are used for report presentations. The capacity of each point plotter is 50 points per minute.

Future plans for the General Missile and Ordnance Systems Data Processing and Computation Center are centered around making it more automatic with the intent to increase efficiency, speed and accuracy. Problems now being worked, such as automatic translation of timing signals for inclusion on oscillograph records and pulse code modulation telemeter data handling, are expected to increase in scope and complexity at the center enlarges its size and capability.★

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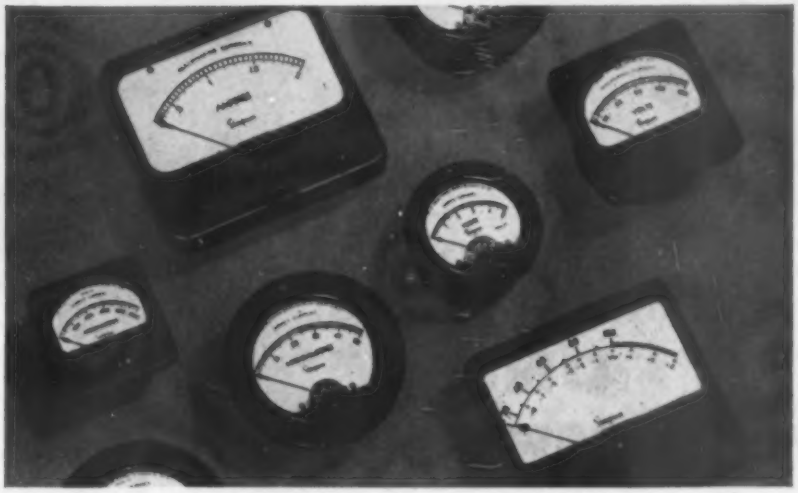

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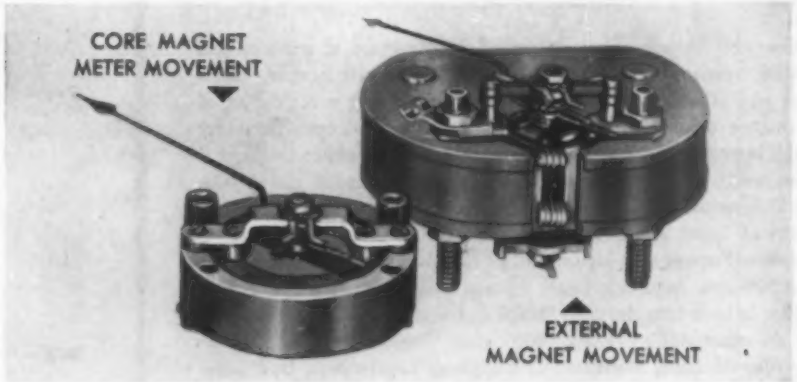

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SPECIFICATION SUMMARY

MODEL 450-1800A TRUE DIFFERENTIAL DC PREAMPLIFIER

Input — Impedance: 200K differentially between terminals (balanced) or 100K each input lead to gnd. (single-ended)
Common mode rejection: at DC, 100 db; to 60 cps, 94 db; 400 cps, 80 db.
Equiv. input drift: ±2 uv for 24 hours
Equiv. input noise: 5 uv peak to peak (0–10 cps), 20 uv (0–1000 cps), 50 uv (0–30 kc)

Output — Low Power Circuit:
Output appears between two cathodes as true push pull signal.
Common mode level of cathodes ±2 volts with respect to ground.
Output capability: ±3 volts into 5000 ohms
±10 volts open circuit
Zero position control *not* active for this output
Freq. response; 3 db down at 30 kc
Linearity: 0.1%
High Power Circuit:
Output appears between two emitters as true push pull signal.
Common mode level of emitters ±2.5 volts with respect to ground.
Preferred load: 50 ohms
Output: ±2.5 volts, ±50 ma
Freq. response; 3 db down at 15 kc
Linearity: 0.5%
Zero position control is operative for high power output ckt.

Gain — Fixed steps 1000, 500, 200, 100, 50, 20
Gain Accuracy 0.5% for D.C.
Smooth gain control covers range between fixed steps

Power Req. — 115 volts, 60 cps, approx. 50 watts

MODEL 450-1100 CARRIER PREAMPLIFIER

Carrier Freq. — 2400 cps (std.); 600, 1200, 4800 cps optional

Carrier Exc. — approx. 4.5–5 volts, depending on transducer imped.

Transducer Imped. — 100 ohms min. - 1000 ohms max.

Input Imped. — approx. 2500 ohms, incl. zero sup. ckt.

Sensitivity — 100 uv rms from transducer (output imped. 1000 ohms or less) gives 1 volt at output under max. output loading

Output — preferred circuit: between one active cathode and one reference cathode
alternate circuit: between active cathode and ground

Output Voltage Capabilities — (a) ±3 volts into 2.2K min. load
(b) ±6 volts into 5K load
(c) ±7.5 volts open ckt.

Output Linearity — better than 0.2% for (a) above

Output Impedance — approx. 1000 ohms, preferred ckt., 500 ohms alternate output ckt.

Freq. Response — 3db at 20% of carrier freq.

Zero Suppression — can suppress 0 to 100% of transducer load (either sense via switch)

Power Req. — 115 volts, 50–400 cps, approx. 30 watts

challenge to industry:

Spaceship Telemetry

communication with moon vehicles feasible now?

by Henry P. Steier

HOW FEASIBLE is telemetering of information between earth and unmanned vehicles orbiting about our moon or planets of the solar system?

Despite dozens of propulsion and vehicle schemes for such orbiting vehicles, little has been said about the telemetry problems. These are usually tossed off lightly. The attitude seems to be "anything is possible if it can be conceived."

Serious thought has been given to telemetry designs for spaceships by Hans Scharla-Nielsen, engineer with Radiation, Inc. In his thinking he has assumed that the primary difference between today's telemetering schemes and those needed for the vast distances of space flight is in the radio frequency link.

Nielsen has gathered the basic design data necessary to take a first look at what happens to space telemetry signals between the transmitting antenna and the receiver.

Much of this information can be put in nomogram form so that it fits a variety of conditions that would be encountered in space telemetry designs for vehicles traveling anywhere from the moon on out to the planet Pluto.

The type of signal level diagram shown in Fig. 1 is useful in showing

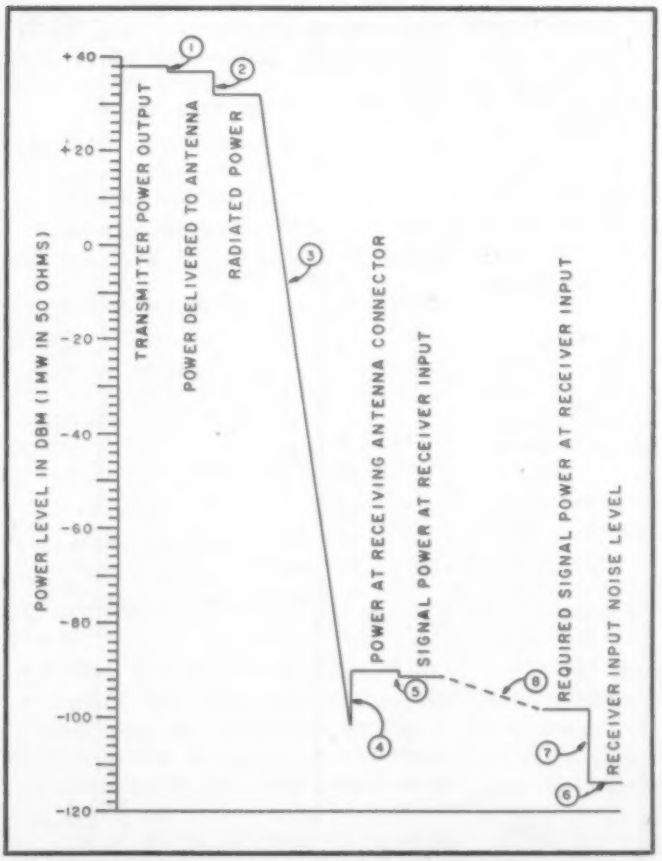


Fig. 1—Steps in signal strength and loss—spaceship to earth.

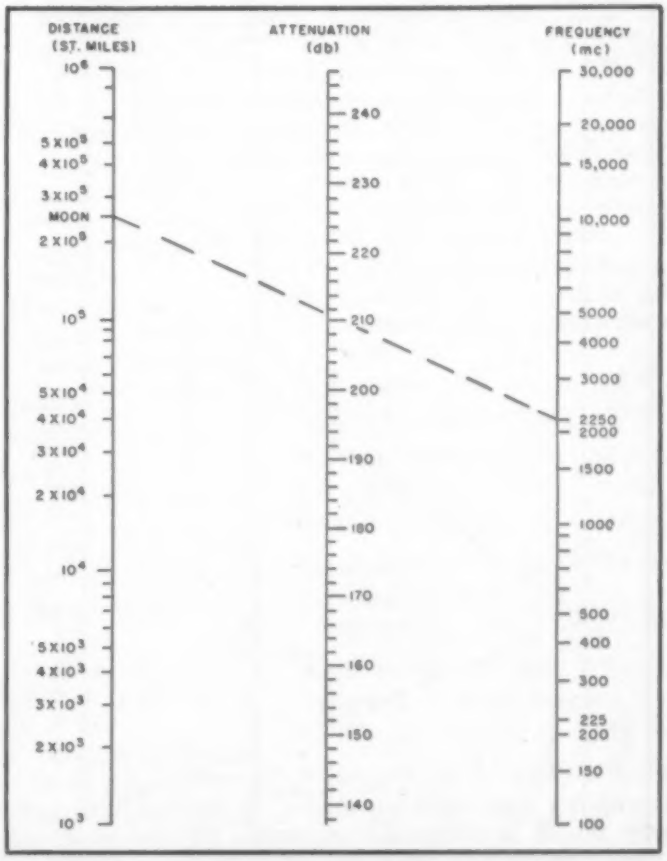


Fig. 2—Nomogram, free space signal attenuation—earth to moon.

the steps in power loss or gain that would be encountered in space transmissions of radio energy.

The plateau at step 1 shows loss between transmitter and its antenna. Step 2 shows transmitter antenna loss (which might, of course, be shown as a gain). Step 3 shows transmission path loss between transmitting and receiving antennas having the same properties in all directions. The path loss is of great significance and would have a most influential effect on just how much could be done with a single telemetering link.

At step 4, a gain is shown because some increase might be obtained from a receiving antenna of good design. Steps 5 to 8 show considerations that must be given at points between the receiving antenna and the output of a useful signal.

Step 8 is interposed as a variable factor that must be built in to take care of unfavorable conditions and some system degredation. Much of what will be learned in first space flights will strongly influence this factor.

An especially important factor related to current technology is the receiver noise level, which is a function of receiver noise bandwidth and the receiver noise figure.

This is identified in the basic loss diagram of Fig. 1 as step 6. Figure 3 shows a nomogram that may be used to determine step 6 and also two scales for receiver noise input level.

These differ by 19 db, which is two orders of magnitude. The scale marked 4°K corresponds to a receiver having a front end at the temperature of liquid helium.

A section of the receiver noise figure scale is marked "MASER." This is the acronym for a new type of atomic amplifier operating on the principle of "microwave amplification by stimulated emission of radiation."

Just getting into the hardware stage, the MASER promises to have revolutionary effects on upping the sensitivity of many types of electronic devices used in communications and detection. This gain is attributable to lack of noise caused by electron flow. The MASER gets its energy from atomic phenomena without electron flow.

The MASER or paramagnetic amplifiers operate at near absolute zero temperature, which corresponds to the lower receiver noise level scale in Fig. 3, and to a noise figure of only up to 4 db. This is much below best available receivers now.

In choosing a space telemetry system design it is necessary to consider signal-to-noise ratio at the receiver input required for a particular signal-to-noise ratio in the output channel.

Together with the inherent noise level, which would be helped by the MASER, noise figures are influenced by the type of modulation employed, detection characteristics and irregular errors introduced.

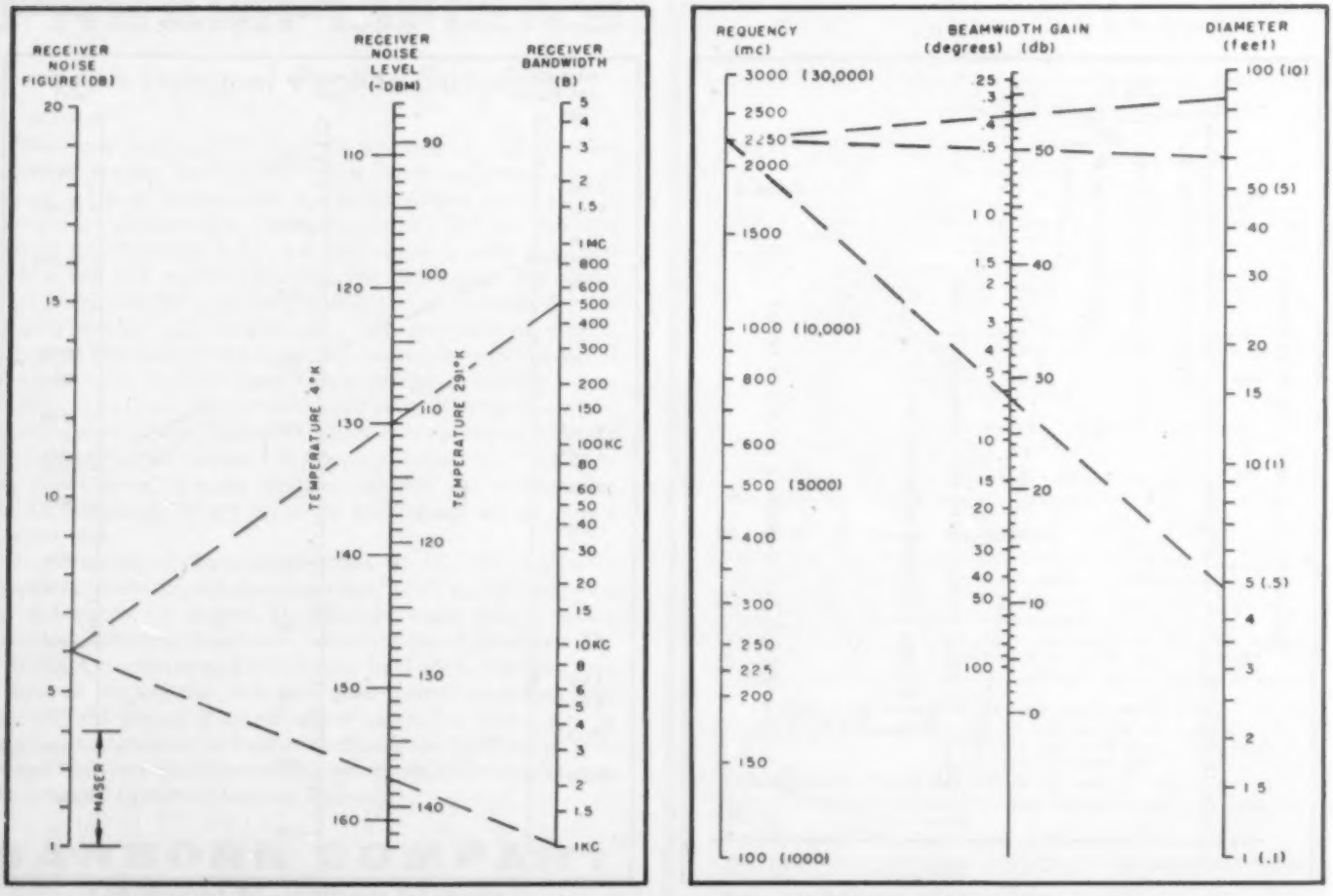
Nielsen said that current standard PCM/FM, FM/FM and PWM/FM systems generally meet their error specifications when the receiver is at its improvement threshold corresponding to about 10 db input signal-to-noise ratio.

Suppose a high-information-capacity moon-orbit vehicle telemeter was required? Starting point in Nielsen's design would be frequency. He selected 2250 megacycles.

This was chosen over the 225 megacycle band because of possible interference from the radio-signal-emitting constellation Sagittarius if narrow-bandwidth receiving antennas in conjunction with low-noise preamplifiers in the 22-mc band were used.

A receiver bandwidth of 500 kilocycles would be chosen as a compromise between high information capacity and system feasibility.

A receiver noise figure of 6 db would be chosen because it represents an available figure. Other numbers chosen would include figures for a 60-



Figs. 3 and 4—Nomograms to determine noise levels in receivers and gain and half power beamwidth of a parabolic antenna.

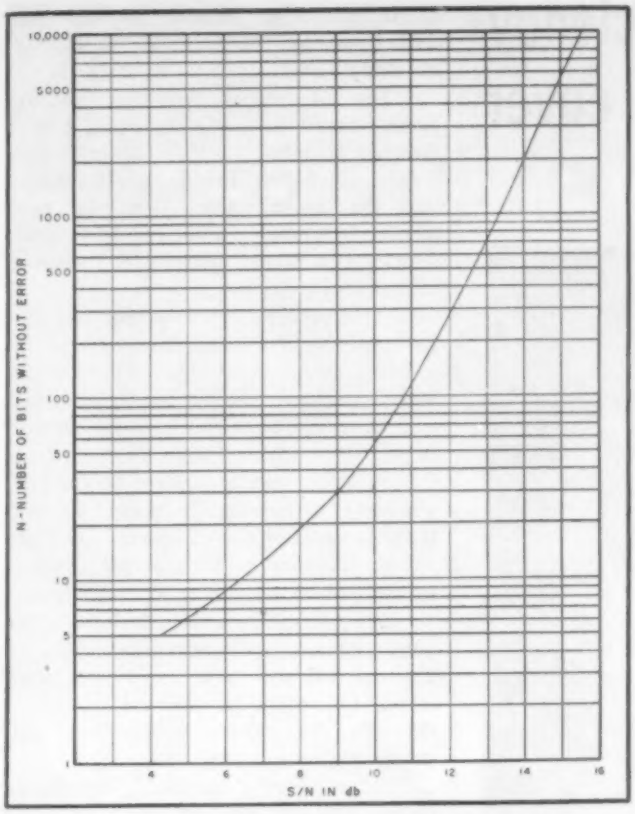


Fig. 5—Total bits without error when bandwidth = bit rate.

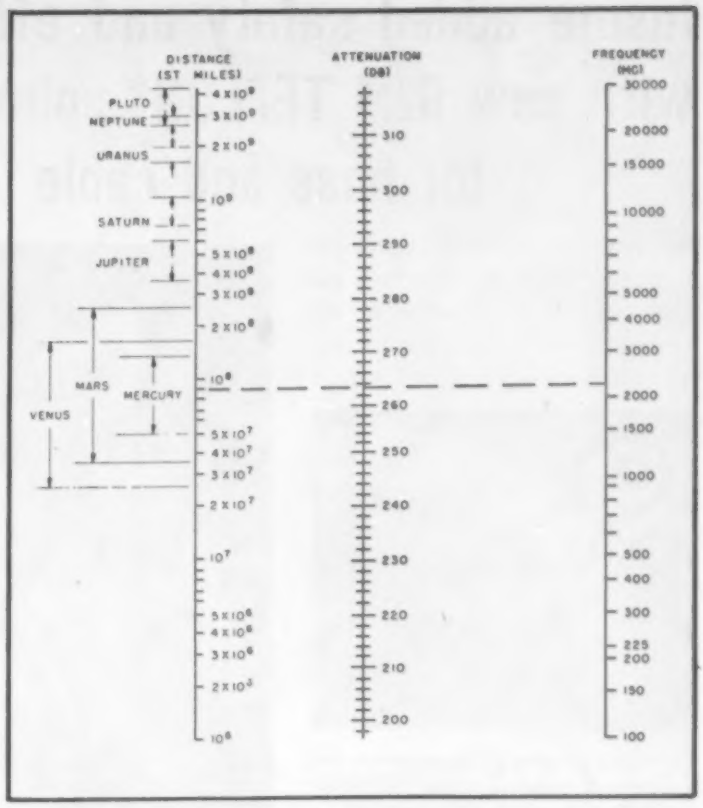


Fig. 6—Nomogram of signal attenuation in free space to Pluto.

foot diameter tracking antenna dish and a 10-watt transmitter.

This antenna is already available in Radiation's TLM-18 system being installed to track ICBMs from the Cape Canaveral, Fla. test site. It has already been announced that this system would have utility for interplanetary rocket programs (m/r, Nov. 1957).

This is how the moon vehicle telemeter design would add up in terms of signal gain and loss (numbers in parentheses refer to Fig. 1 steps):

(6) Rcvr. noise level	−111 dbm
(7) Required signal-noise	+16 dbm
Rcvr. sensitivity	−95 dbm
(5) Rcvr. line loss	+1 db
(4) Rcvr. antenna gain ..	−50 db
Level req'd at recvr. antenna	−144 dbm
Path loss at 260,000 miles	212 db
Xmit. power-ant. gain req'd.	68 db
Assuming 10-watts for xmitr.	+40 dbm
(2) Xmit. ant. gain req'd. .	28 db

Path loss information was obtained from the nomogram of Fig. 2, which shows free-space loss between antennas having the same properties in all directions.

Fig. 4 shows that a 60-foot ground-based tracking antenna would give 50 db of directivity gain and a ½ degree bandwidth at 2250 mc. It also shows that for the moon vehicle antenna-gain required, a 4.8-foot reflector is needed. It has a 6½ degree beamwidth.

Nielsen reasoned this could be a dish of the umbrella type. It would be extended after the vehicle left the earth's atmosphere and act as both the transmitting and receiving antenna.

Either the vehicle or the antenna would be automatically positioned to point the antenna to a very high-powered beacon signal and command transmitter on the ground.

Fig. 5 shows the number of bits of information that can be handled without error by a PCM/FM system when the radio frequency bandwidth is equal to the bit rate. It is shown as a function of signal-to-noise level in db.

From this information the moon system looks practical now. The presently available ICBM tracking radars will work with an "S" band feed, although they are presently operating in the lower-frequency regular telemetry band.

What happens to the feasibility when a Mars ship telemeter is laid out for design?

The amount of information that can be transmitted drops drastically. Complexities of receiver and antenna design mount beyond, or border the edge of, present knowledge.

For the hypothetical Mars system, Nielsen would use the same 2250-mc frequency and the receiver noise figure of 6 db. Because of the increased range and necessity to keep the receiver noise level as low as possible, the receiver bandwidth is reduced to 1 kc.

Fig. 3 shows a plot of noise level with a 1-kc system when 6 db is the rated receiver noise figure. Complication would be added to the Mars system since sophisticated circuitry would be needed to take care of Doppler shift as the radial velocity between transmitter and receiver varies.

This is how the Mars ship telemeter design would add up in terms of gain and loss (number in parenthesis refer to Fig. 1 steps):

(6) Rcvr. noise level	−138 db
(7) Required signal-to-noise	+16 db
Rcvr. sensitivity	−122 dbm
(5) Rcvr. line loss	+1 db
(4) Rcvr. ant. gain	−53 db
Level req'd at rcvr. ant.	−174 dbm
Path loss to Mars (average)	263 db
Xmit. power ant. gain	89 db
Assuming 10 watts for xmit.	+40 dbm
(2) Xmit. ant. gain req'd	49 db

Path loss information was obtained from the nomogram of Fig. 6, which shows losses for paths to various plan-

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ets in our solar system between antennas having the same properties in all directions.

Fig. 4 shows that an 84-foot ground-based tracking antenna would give the required 53-db gain and about a 0.36-degree bandwidth. It also shows that the moon vehicle antenna gain required would result in a 60-foot diameter reflector with a 0.5 degree beamwidth.

The vehicle antenna required has an imposing diameter for carriage by a Mars research vehicle. The vehicle would probably be of relatively small size in initial attempts to orbit around Mars.

Possible solution might be the paraballoon technique. It uses two collapsible paraboloids of fabric. They are joined together at their edges. One is metallized to act as antenna reflector.

The fabric assembly is inflated by air to form a semirigid antenna system. Carried by the Mars ship, such an assembly could be carried collapsed through the earth's atmosphere and then inflated in outer space.

The very narrow, 0.5-degree beamwidth of the antenna considered in this design would require very advanced tracking circuitry to keep it "on target" with the ground-based receiving system.

Path loss over the great distance to Mars reaches the enormous figure of 263 db. Fig. 6 shows that in the case of Pluto this figure goes up to 294 db.

There are some alternative approaches that might be taken to get around system range difficulties in different orbital vehicles.

One of these is an increase of transmitter power. Weight limitation may be the deciding factor here. Presently available power supplies require about 2½ pounds of battery weight for each 100 watt-hours.

Solar cells are a possibility for a power source. Those available produce about 2.9 watts per pound. Increases in this output may be expected in the near future.

An increase in frequency would aid the antenna beamwidth and gain prospects. However, successful transmission of frequencies much higher than those contemplated in Nielsen's theoretical designs would be dependent upon characteristics of the ionosphere and the atmosphere. Another handicap with higher frequency might be a requirement for a mechanically ultra-accurate antenna and increased burden on the tracking system.

Trade-offs might be made between antenna gain and increased transmitter power and more sensitive receivers. Progress in lowering receiver noise

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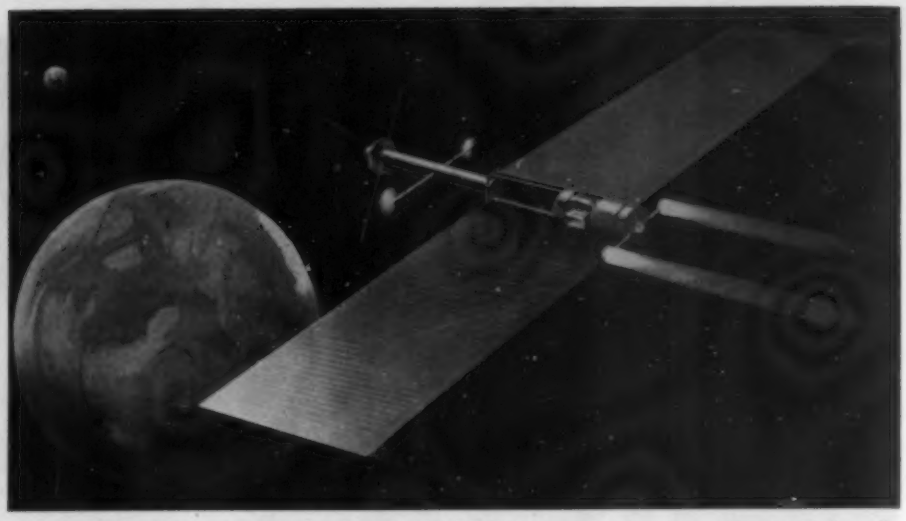

Fig. 7—Rocketdyne's concept for Project SNOOPER, an interplanetary ion-propelled craft.

figures is being made. Nielsen believes the lowering of reference noise level for an ideal receiver now promises to provide the next breakthrough in the receiver art. This would come about through the MASER amplifier.

But, he said, "it appears that incorporations of the (MASER) amplifiers in receivers operating much below about 2000 megacycles or so would not produce a system advantage since the receiver noise level would be exceeded by cosmic or galactic noise at the receiver input."

He also notes that the best method of signal detection is not always used in present telemetry systems. Data given in Fig. 5 are for a conventional amplitude modulation detector. With synchronous detection in AM systems there is potential for increasing signal-to-noise ratio at the output by a factor of 3 db, according to Nielsen.

Possibility of a more remunerative approach to increasing system range could come through use of the most efficient means of encoding data. Improved spaceship telemetry might come through a reduction of bandwidth after a critical evaluation of the information rate necessary for an experiment.

One approach that might be taken would include a sophisticated system with asynchronous decoders and variable bandwidth receivers. The information rate would be controlled by ground command through an additional RF link. This would be programmed to use the various rates most efficiently.

Also the command link could control programming of transducer outputs to data channels of various capacities according to decisions made by a ground computer.★

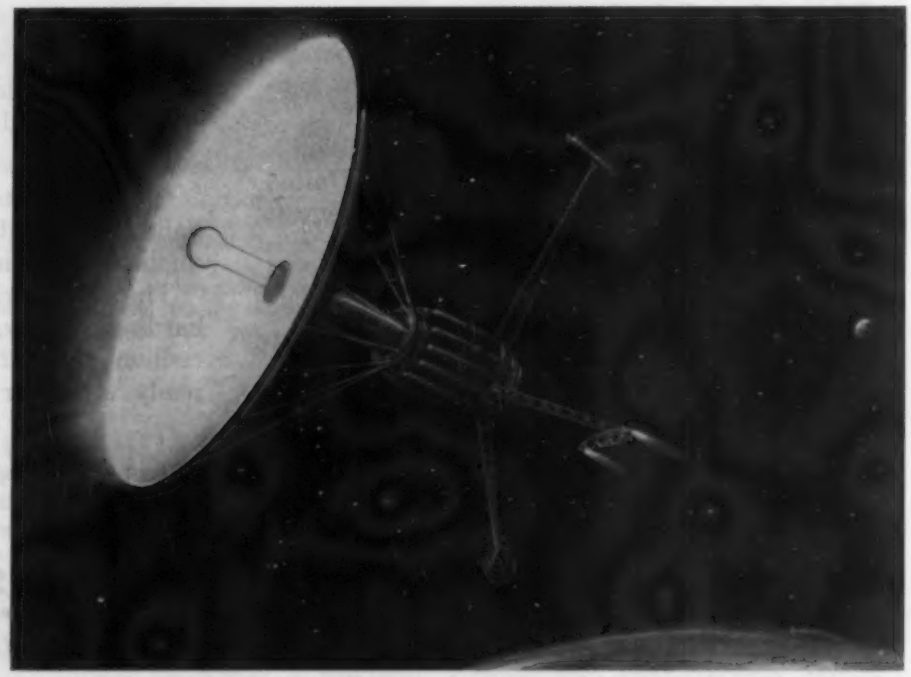

Fig. 8—Solar-powered spaceship conceived by Convair's Krafft Ehricke for interplanetary travel.

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PAUL D. CASTENHOLZ, Pacific combat veteran, graduated B.Sc. (Eng.), UCLA 1949. From research engineer his grasp of rocket engine work raised him through a supervisory post in experimental development to assistant group leader in combustion devices, and then to group leader of experimental engines. Recently completed requirements for his MSc. Relaxes with hi-fi, fishing and back packing.

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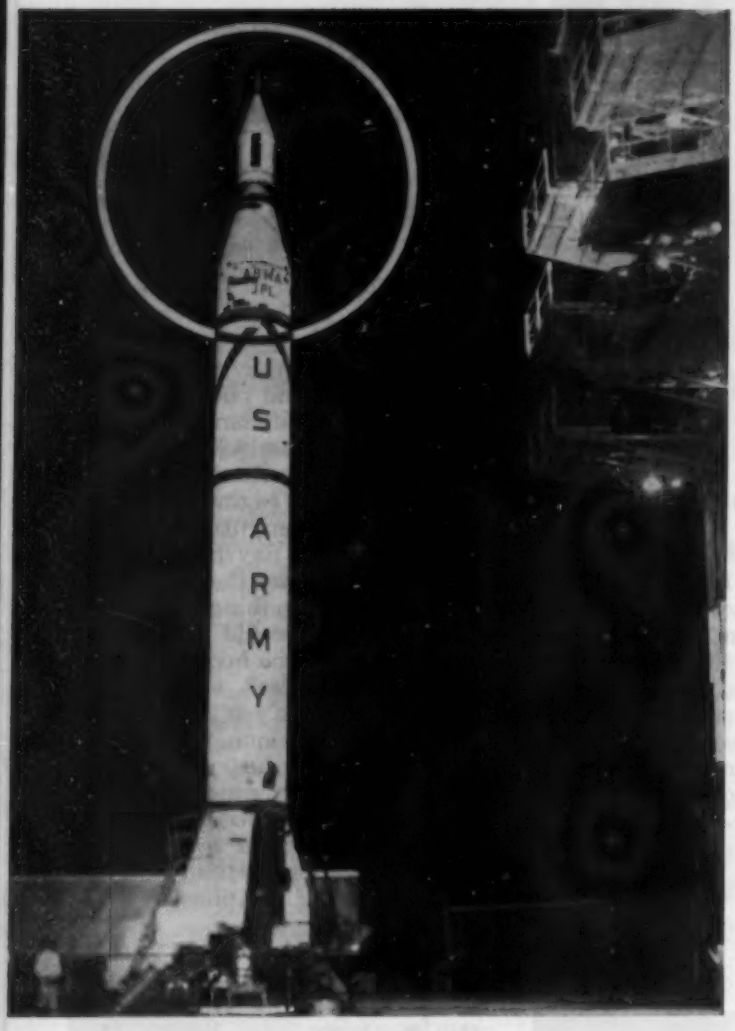
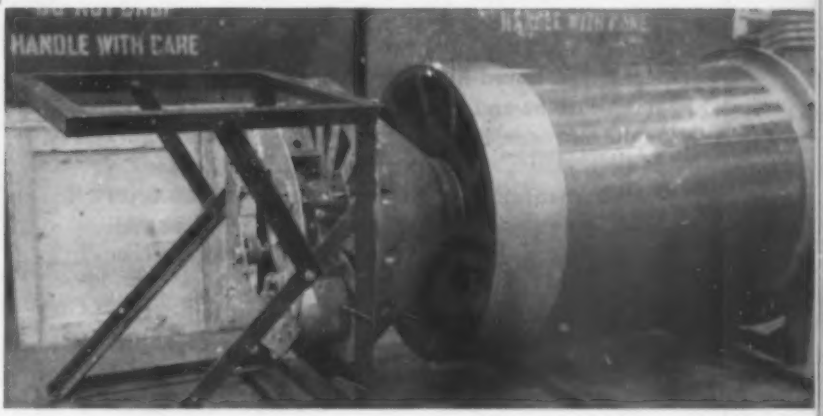


Spin-stabilizing the JUPITER-C

AS m/r went to press a large four-stage Army research rocket was positioned on its pad in preparation for launching at Cape Canaveral, Fla. The firing will depend on the rapidity and smoothness of the system checkout. Its payload will be a small cylindrical satellite mounted atop the solid-propellant fourth stage of the carrier vehicle. Shortly before the countdown reaches zero, a switch will be thrown and a large aluminum "bucket," housing the last three stages of the rocket, will start spinning rapidly. These spin-stabilized stages will separate from the first stage in the upper rarefied regions of the atmosphere and will continue on their way following a predetermined flight trajectory because of the gyroscopic stability induced by the spinning action. This will be the Army's first attempt at launching a satellite with the JUPITER-C or JUNO I (the name suggested to eliminate confusion with the JUPITER IRBM), but not the first trial for the vehicle or the spin mechanism. These were proven in missile nose cone re-entry tests last year.★

Below—Technicians of Reynolds Metals Co. (fabricators of the REDSTONE and JUPITER-C) make final profile concentric tests on nose section of JUPITER-C's first stage REDSTONE. Right—Highly polished nose section (warhead on operational REDSTONEs) is attached to guidance and control housing section.



Above—A finished "bucket" mounted on the spinning mechanism housing is prepared for shipment. The 30-inch-diameter housing will enclose 15 six-inch diameter rockets in two concentric clusters (11 in the second stage and 4 in the third stage). Above right—The aluminum spinner gear framework. Openings for the second-stage rocket's exhaust can be seen in the lower ring. Right—A view of the spinner gear housing attached to the rocket "bucket." Spin rate of the upper stages is reported to be above 50 rpm. The REDSTONE first stage will contain all guidance equipment. Final stage will fire at apex of ballistic trajectory.

Below—Missile technicians at Army Ballistic Missile Agency in Huntsville, Ala. attach the satellite to top of the 4-foot fourth-stage rocket. Satellite plus the expended rocket shell will result in an orbiting unit 6 ft. by 6 in.

Above—Complete guidance, control and spin-stabilization framework ready for delivery to Army at ABMA. Total of 11 JUPITER-Cs were manufactured. Nine remain for satellite program.

NEW LIQUID NITROGEN PUMP PROVIDES HIGH PRESSURE GAS FOR MISSILES AND ROCKETS

It solves many missile systems problems and is highly useful for aircraft cooling systems and ground support equipment

A compact, extremely light weight unit, it can be used to supply high pressure nitrogen gas in almost unlimited applications. A positive displacement type liquid nitrogen pump, it is driven by a small turbine and is installed in a vacuum jacketed liquid nitrogen container which serves as a supply reservoir. By passing the liquid nitrogen through a heat exchanger, it is converted to a gas at 3000 psi which serves to drive the turbine and pump as well as furnish a gas supply for missiles, aircraft or other uses.

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3. Cooling of electronic equipment.
4. Local cooling of aerodynamic surfaces.
5. Provision of clean inert pneumatic system working fluid.
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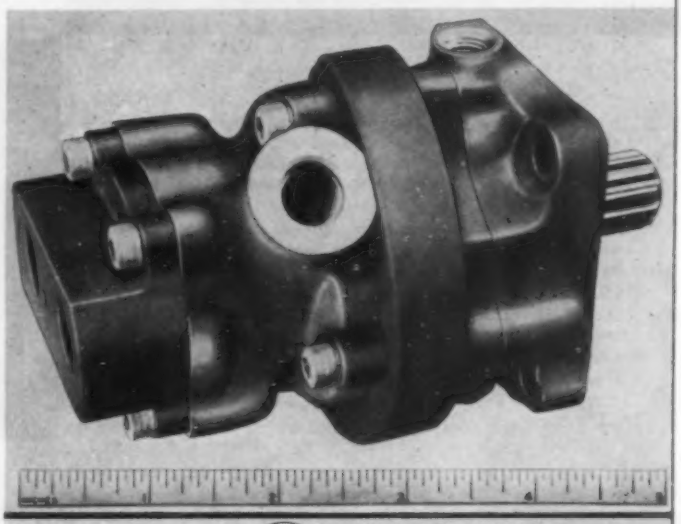
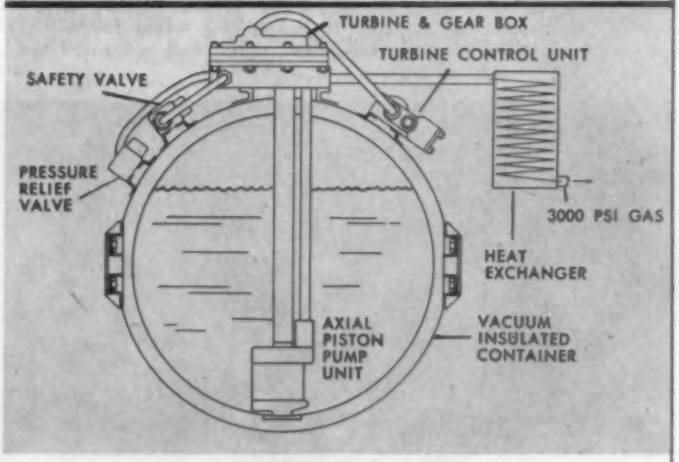
7. Provision of fire extinguisher fluid.
8. Provision of ground supply of high pressure nitrogen.

By combining several of these functions in one system, substantial weight savings can be made by elimination of duplicate equipment.

For complete performance data or further information on how this unit may be used to solve your problems, please contact our Application Engineering Department.





SCHEMATIC DRAWING OF LIQUID NITROGEN PUMPING UNIT

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Power Packages for Medium-sized Missiles

Canadian industry using and testing variety of types

by A. E. Maine and E. Wall

THE ELECTRICAL requirements of missiles vary widely according to overall size, the type of guidance and control employed and the kind of mission encountered. On the one hand there is the proximity artillery shell employing tiny batteries or ram-driven turbine alternators; and on the other, very large ICBMs whose power needs, though classified, may be expected to be substantial. Between these extremes lie a large number of missile configurations, mostly of the air-to-air and surface-to-air type, with total weights of up to several hundred pounds, whose power needs are broadly similar, and it is with this group of weapons that this article is concerned.

The authors are associated with The de Havilland Aircraft of Canada, Ltd., guided missile division.

At the present time a broad distinction can be made in regard to power-unit types for the small- and medium-sized missiles: they are either static units employing batteries or rotary units consisting essentially of an energy source, a turbine and a high-speed alternator. In the latter case, the energy source may be compressed gas, solid propellant or a liquid monofuel.

The choice of which of these to use in a given situation is not usually a clear-cut matter since their respective advantages and disadvantages overlap in a somewhat complicated manner.

Within certain limits, the physical size of many electronic components and circuit arrangements diminishes as the supply frequency is raised. Consequently there is considerable merit in choosing basic supply frequencies well into the audio frequency band. An exception to this general trend concerns electric motors, where design difficulties and falling performance at abnormally high supply frequencies set a definite limitation. For this reason it is not unusual to divide the total electrical demand into two parts, for motor and electronic loads, and supply each from a separate generator sharing a common shaft.

The size of the high-frequency generator mentioned earlier is approximately proportional to the reciprocal of the shaft speed. It follows that the higher this can be made, the smaller the generator for a given power output. The impulse turbine prime mover matches the required generator drive very well and substantial horsepower rating at speeds up to 100,000 rpm can be realized in a few cubic inches of space. At these speeds, slip rings and commutators are virtually ruled out in generator construction, owing to pro-

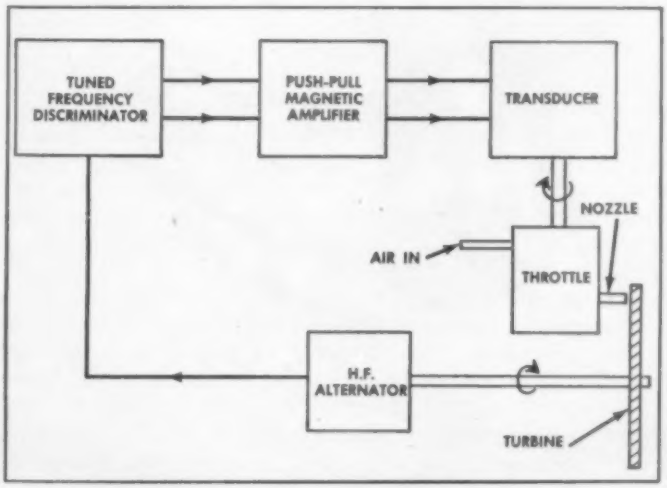

Fig. 1—Block diagram of proportional speed control.

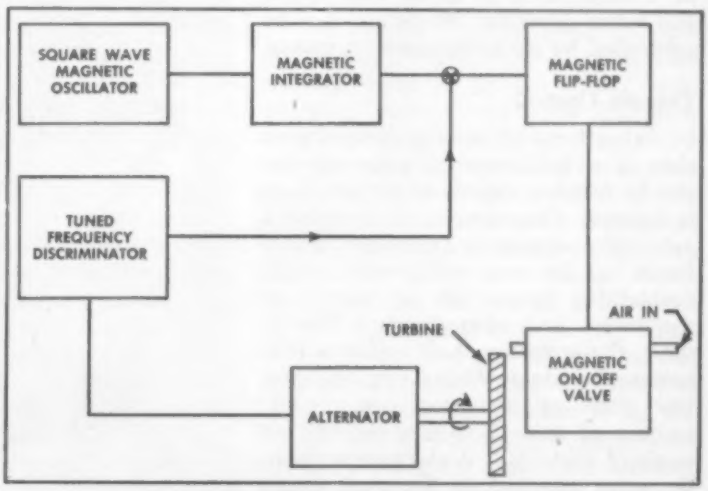

Fig. 2—Block diagram of on-off type speed control.

hibitive friction losses and significant degradation of reliability. Therefore, the machines must be of the permanent magnet excited type or of the so-called polar inductor configuration.

Speed and voltage control of the missile generators are usually required and the necessary control means become an integral part of the whole power unit. Such units, then, characteristically are densely packed electromechanical assemblies and almost fully self-contained in all respects.

In order to give a better appreciation of the missile power unit outline presented so far, some aspects of typical compressed-air- (or nitrogen-) driven units should be considered.

Pneumatic System

The energy storage device is a steel bottle of spherical, cylindrical or toroidal shape, depending on local missile topography, fitted with a high-pressure nonreturn valve for charging purposes. Leading from the bottle is a starting device which may be either a squib-operated bursting disc or a magnetically operated servo valve with mechanical or pneumatic latch-on. The primary function of this valve is to initiate full air flow to the turbine within milliseconds of receiving an electrical pulse.

Air from the starting valve is led to the pressure-reducing valve, where the high storage pressure is reduced to a lower value optimized for the particular turbine used. At the downstream side of the reducing valve a branched union is often fitted to enable check-running of the power unit from a low-pressure source. This is a useful feature since the required pressures and flows can usually be supplied from conventional industrial compressors, which usually have a wide distribution at military centers.

The air from the reducing valve is routed to the turbine wheel nozzles either directly or through some form of control valve in order that speed, and hence generator frequency, may be controlled by electro-pneumatic means.

Throttle Control

One form of throttle control consists of a balanced-type magnetic circuit in which a double-ended armature is located. The static part includes a pair of permanent magnets whose fluxes link the rotor and provide a high centralizing force. Coils are wound on the device, and when currents flow in these, the armature shaft rotates a proportional amount. With proper design a few watts of excitation can provide torques of some 2 in.-lbs. through an angle of about 20°. A sleeve-type throttle valve attached to the shaft determines the air flow to the turbine.

An alternative flow controller, quite unlike the proportional transducer described, is the magnetic on/off valve. In some circumstances this may be used successfully for speed control. As the name implies, the valve is either open or shut, and reliance is placed on the high inertia of the rotating parts in the system to smooth out the switching transients. Systems employing these valves usually operate so that the valve is cycled on and off at a fixed frequency and the time of dwell in each condition is made controllable. This technique confers upon an essentially two-state device a measure of proportion.

Valves for this purpose depart significantly in design from conventional magnetic shutoff types since they must be very fast-acting and operate with a minimum of excitation. Both of these requirements can be met in a design where a small steel ball serves as both the moving armature and pneumatic shutoff device, working directly into a suitable seating. The valve described appears more suitable for relatively crude speed controls or for "hot" gas systems provided that operating temperatures are not too severe and spill valves are available. A possible objection to the scheme is the reaction of the electrical transients back on the main generator outputs.

Full-admission turbine designs are usually inconvenient for small missile applications and consequently partial-admission schemes, with a few nozzles or perhaps only one, are quite common. Wheels are made from aluminum alloy or sometimes magnesium, turned and profile-milled from the solid. Diameters are usually kept to the maximum permissible since efficiency improves as the ratio of peripheral speed to gas velocity increases. Nozzle and bucket design represent areas of much research and development, and specialized test facilities are required in order to assess efficiencies, gas processes, nozzle performance and other important matters.

Often, the time taken between the turbine at standstill to the system running at full speed with the transient completed is of considerable importance. In this case auxiliary nozzles, operating only in the starting condition, can be supplied from a high-pressure point through a mechanical delay so that the system reaches steady-state running in a time less than one second.

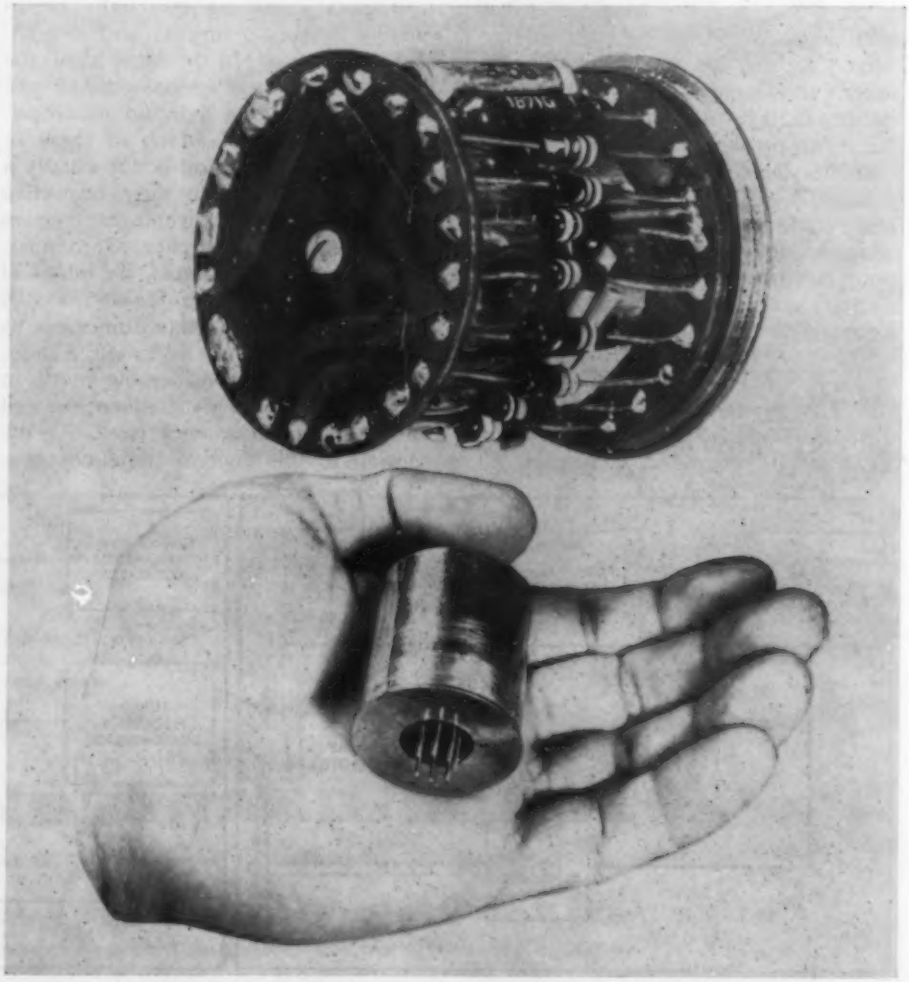

Fig. 3—Typical voltage regulator unit with regulation accuracy of two per cent.

Electrical Generators

The lower-frequency generators for driving motor leads are mostly three-phase types with a permanent magnet rotor. Close voltage regulation is not usually required and a machine with a well-stabilized magnet is sufficient for the purpose. In some circumstances capacitor-excited induction generators are attractive possibilities, especially as this type of machine can be used as a motor for maintaining correct shaft speed in the prelaunch condition. In isolated cases voltage regulation can be provided by means of external schemes—notably magnetic amplifiers, designed to absorb only a fraction of the line voltage.

Occasionally the motor load power required is relatively small, and it is sometimes more convenient to dispense with a separate generator and use instead ferroresonant magnetic frequency dividers energized from the high-frequency machine or to generate the required power using wholly electronic means.

In the de Havilland Co. a very satisfactory high-speed, low-frequency machine has been successfully developed from a well-established principle. It may be described as a permanent magnet synchronous motor-alternator incorporating a squirrel-cage induction rotor. The machine runs up as an induction motor when its windings are excited from an aircraft or ground installation, and upon reaching a small slip, pulls into synchronism automatically, remaining so over a wide range of shaft loads. However, when the shaft is driven by a prime mover, it behaves as a normal permanent-magnet generator, the squirrel cage taking no part in the action. This machine permits synchronization of the missile and external control circuits before launch, and of course eliminates the starting delay common to nonmotoring schemes. As mentioned earlier, no rotating electrical contacts are involved.

A polar inductor alternator for generating the high frequency power comprises a laminated stator and a simple nonwound salient pole rotor. When rotated the magnetic flux generated by the field excitation applied to opposite quadrants of the machine is switched, and armature windings also wound on the stator embrace the changing field and produce the high-frequency output. The steady field may be created by means of a permanent magnet or conventional wound fields or both. If windings are used, control and regulation of the output voltage may be readily achieved.

The class of machine described usually possesses a relatively high internal inductance, and it is common practice to series-tune the main windings in order to increase the available load power. Prevention of waveform distortion due to the connection of nonlinear reactive loads such as magnetic amplifiers can be secured by means of special filter techniques. Power outputs of up to 750 watts per pound machine weight are readily possible.

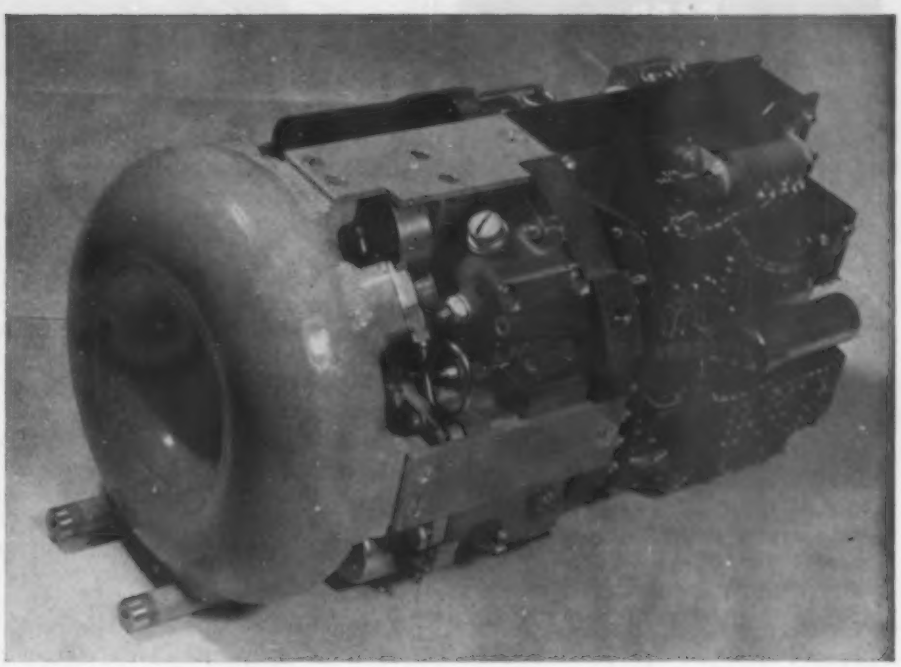

Fig. 4—Air-driven missile power unit with integral power pack for regulated dc voltages.

Speed-control Circuits

Fig. 1 shows a simple arrangement for providing speed control based on the use of the proportional transducer described earlier. A pair of series resonant circuits tuned at each side of the required frequency are excited from the HF generator output. These feed full wave rectifiers. DC signals from the rectifier bridges are applied to a pair of magnetic amplifier control coils connected in opposition. The push-pull magnetic amplifier in turn controls the differential currents to the proportional throttle and hence the air flow. If the speed changes from the nominal value, the effective magnetic amplifier control signal departs from zero and appropriate corrective movement of the throttle takes place.

Turning to the dynamics of the system, by far the most prominent term is the first order lag representing the relationship between a step change of throttle setting and the corresponding shaft velocity. The long time-constant involved overshadows all other dynamics; consequently substantial loop gains giving excellent regulation are possible with good stability. With the loop closed, the long time-constant is effectively divided by the loop gain so that action is fast and well damped.

Fig. 2 shows a block diagram of a speed-control scheme based on the magnetic on/off valve. A square wave magnetic oscillator passes a signal to a second magnetic amplifier, which behaves as an integrator and produces symmetrical triangular waves. These waves are passed to a summing point where a dc bias proportional to frequency deviation is added. The combined output is fed to a magnetic switch amplifier which changes its state each time the combined signal changes sign. The ball valve being excited from the on/off amplifier moves in correspondence.

The effect of the dc bias is to control the points in the triangular waves at which the polarity changes; consequently the "variable time of dwell" type of proportional control mentioned earlier is provided.

A further type of speed control, which has the advantage of placing no moving parts in the gas stream, employs an eddy-current brake disc fitted to the rotating shaft. The disc, which may be the turbine wheel itself, runs in the gap of a simple electromagnetic yoke and the electrical excitation applied to this determines the retardation effect.

Normally, the system is designed so that the braking effect is very small at maximum load and the control circuit replaces shaft load as electrical power is reduced elsewhere in the missile system. Turbine and nozzles can be optimized under practically constant load conditions. The scheme is therefore quite attractive, especially for hot

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gas units, provided the pressure regulation is good.

Voltage Regulation

Fig. 3 shows a photograph of a typical missile voltage regulator unit capable of a regulation accuracy of ±2 per cent for a generator rated at several hundred watts.

A dc signal proportional to the average value of the line voltage is applied to a bridge containing Zener silicon reference diodes, and the design factors are chosen such that the bridge is substantially balanced at the nominal ac line voltage. The bridge output is led to the control coil of a magnetic amplifier which in turn feeds the field coils of the high frequency machine. Strong negative current feedback is applied to raise the amplifier output resistance, thereby shortening the field time constant and eliminating the effects of temperature changes. As for the frequency control, a dominant lag is provided—in this case by the magnetic amplifier—and a fast-acting, stable regulator results, free from special networks and intrinsically simple and reliable.

Sometimes the missile load is almost perfectly constant or, alternatively, a fairly wide line-voltage tolerance is acceptable. In such cases a closed loop control is not necessary and is replaced by a device which supplies constant current to the machine field. A favourable element that may be used for this purpose is a magnetic amplifier equipped with positive feedback to give infinite gain.

Typical Missile Packaged Unit

Fig. 4 shows a general assembly view of an air-driven unit. The air bottle is of toroidal shape and is mounted at the front of the unit forward of the turbine and pneumatic devices. The HF machine and permanent-magnet low-frequency alternator are located at the rear.

This unit does not have the motoring feature, but does contain the missile powerpack as an integral part. This takes the form of a number of detachable strips each producing and regulating a particular dc voltage used directly by the missile circuits. Filament voltages are also supplied by the unit.

Solid-propellant Power Unit

An early type turbine alternator with a solid-propellant energy source was designed by the de Havilland Propeller Co. of the UK. Quite different problems arise in the design of hot units because of the gas temperature, which usually exceeds 1200°C. Pressure control and filtering also constitute major design obstacles and speed control means are not easy. In spite of the high temperature it is not unusual to employ light-alloy turbine wheels, which are not dangerously heated owing to the short dwell time in the gas stream. Steel wheels are also used and have the advantage of higher inertia in some control schemes. Generally speaking, it is desirable to use a dissipative form of speed control, although throttles can be used, provided the filtering is reasonably good and adequate force is available to actuate the throttle. Here a powerful magnetic relay controls a wide clearance spool valve, which in turn admits bled-off and filtered hot gas to a ram-type servo amplifier. Movements of the ram are communicated back to the relay by means of a mechanical linkage, this feedback loop acting to position the ram in a proportional manner. Attached to the ram, which can exert a

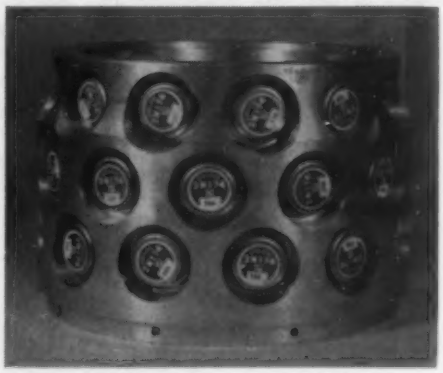

Fig. 5—Heat sink casting for transistors.

force of up to 100 lbs. is a translatory-type throttle controlling the admission of gas to the wheel. The relay coils are energized from the type of amplifier and signal source described for the air turbine.

Static Battery Power Supplies

Power supplies for test missiles often consist of a collection of dry batteries giving directly whatever operating voltages are required by the missile circuits. Occasionally a rotary converter is included with the battery pack for particular ac or dc outputs.

A somewhat more convenient arrangement, also applicable to test missiles, consists of a single secondary battery, usually of 28v dc rating, feeding vibrator-type powerpacks. The arrangement is useful since only a single external supply is needed to operate the circuits before the missile is launched, at which time the missile battery is not normally in use.

Neither of these schemes are attractive operationally, notably because of the poor logistics situation and second-order reliability. The transistor, however, represents a very effective dc power conversion means. Systems employing the latest advances in battery

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technology and refined transistors and associated circuits represent a strong challenge to other types of power unit in certain favourable circumstances. The later provision is made because, being a different sort of device, it has different properties. It is always most important to relate power unit features to the application and avoid the concept of one scheme merely competing with another.

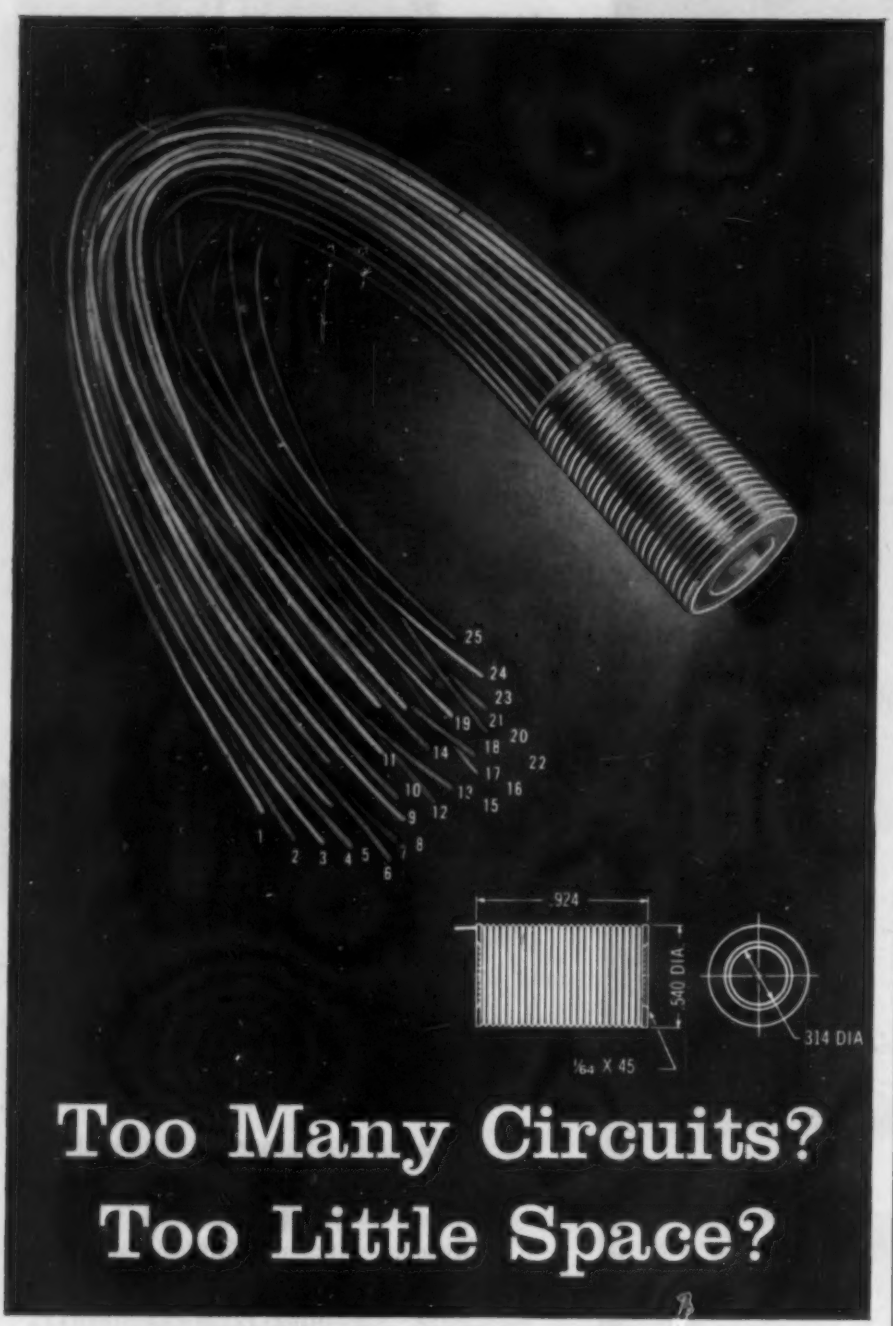
Transistorized Supply

Fig. 5 shows the forward end of a proposed missile power unit which before launch is supplied from the 28v dc aircraft battery. At launch, the "one-shot" battery is actuated and the missile continues its mission, supplying power to its own converters. The assumed outputs, which are well within present-day techniques, are 350 watts of 400 cps power and 400 va of 2.5 kc power, the voltage regulation in each case being about two per cent.

The 400 cps section starts with a stable oscillator whose output feeds a phase shifter containing a dc variable inductor. Two signals at 0° and 90° relative phasing are amplified and filtered in limiting amplifiers. Applied to a "T" transformer, they form the secondary from which a 400 cps signal is derived. The phasing of the two input signals is monitored by a phase-sensitive detector and any departure from 90° results in a dc control signal which adjusts the variable inductor in the phase shift bridge so as to reestablish the required relationship. This phase lock circuit can be made to operate satisfactorily over an appreciable frequency range.

The three-phase signal is applied to a group of driver stages which in turn feed the main power amplifiers, each containing the requiste number of transistors connected in series or parallel push-pull. Negative voltage feedback is applied to each power and driver stage, and overall feedback to give the required voltage reference is taken from one output phase back to the oscillator.

The 2.5 kc channel is arranged in basically the same way except, of course, there is no need for the phase splitting and lock circuits. The unit shown in Fig. 5 is a heat sink casting carrying the power transistors, used in the forward end of an experimental power unit. Two such units are used, with the major part of the circuit components and the one shot battery carried in the cylindrical space between them.★



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Redstone and Jupiter Guidance Share Production Line

inertial systems built in same manufacturing facility

THE U.S. ARMY recently released first pictures of the *Redstone/Jupiter* inertial guidance system production line at Ford Instrument Co., Long Island City, N.Y.

Because of the similarity of *Redstone* and *Jupiter* guidance components, it has been possible to use the same production line for a programmed phase-in of *Jupiter* manufacture. The first all-inertial guidance systems produced in the United States were manufactured by this company and the first system actively guided a *Redstone* missile in April 1955. Currently assisting in production are the Sperry Farragut and Sperry Gyroscope divisions of Sperry Rand Corp.

These guidance systems had their beginnings in an inertial guidance system used as far back as 1937 to guide the German A-5 missile launched from Peenemunde. Outgrowth of this was the V-2 guidance system developed by Dr. Wehrner von Braun with many of the same associates who developed the *Redstone* and *Jupiter* systems at the Army Ballistic Missile Agency. The system is of the conventional all-inertial type except that the stabilizing gyros and integrating gyro accelerometers use air bearings.

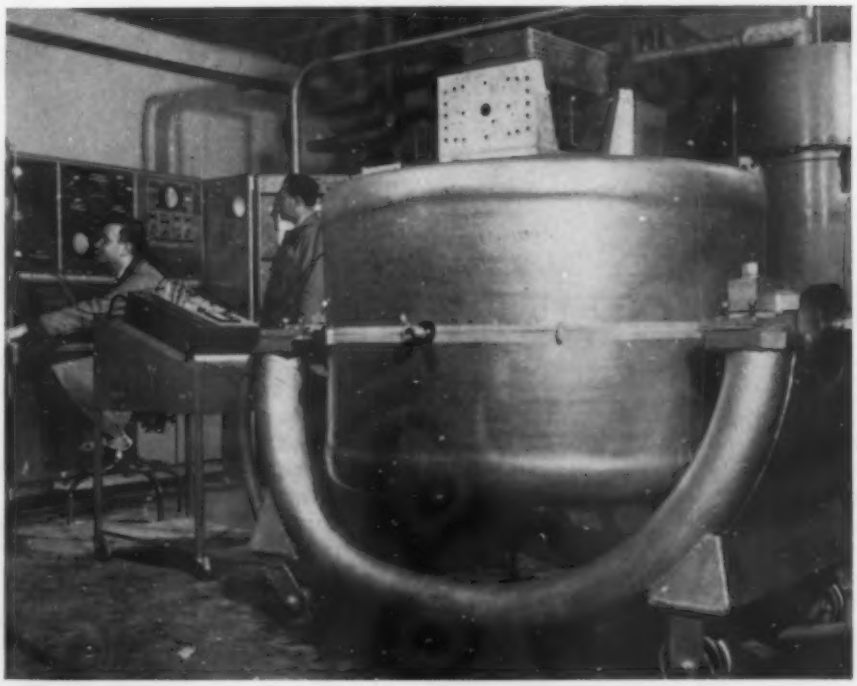
Gen. Medaris, head of the Army Ballistic Missile Agency has declared, "Inertial guidance gives these missiles an all-weather operating capability and makes them absolutely immune to electronic countermeasures. The inertial system," he concluded, "has successfully guided the flight of many *Redstone* missiles and has been used successfully in the *Jupiter* missile."★

Stabilized platforms in final assembly and test prior to shipment to ABMA for installation in missile. Platform shown in foreground has air-bearing gyros and accelerometers removed.

Test engineer making final check of air-bearing gyro before assembling to stabilized platform. All test and assembly operations are carried out in the controlled-environment laboratories.

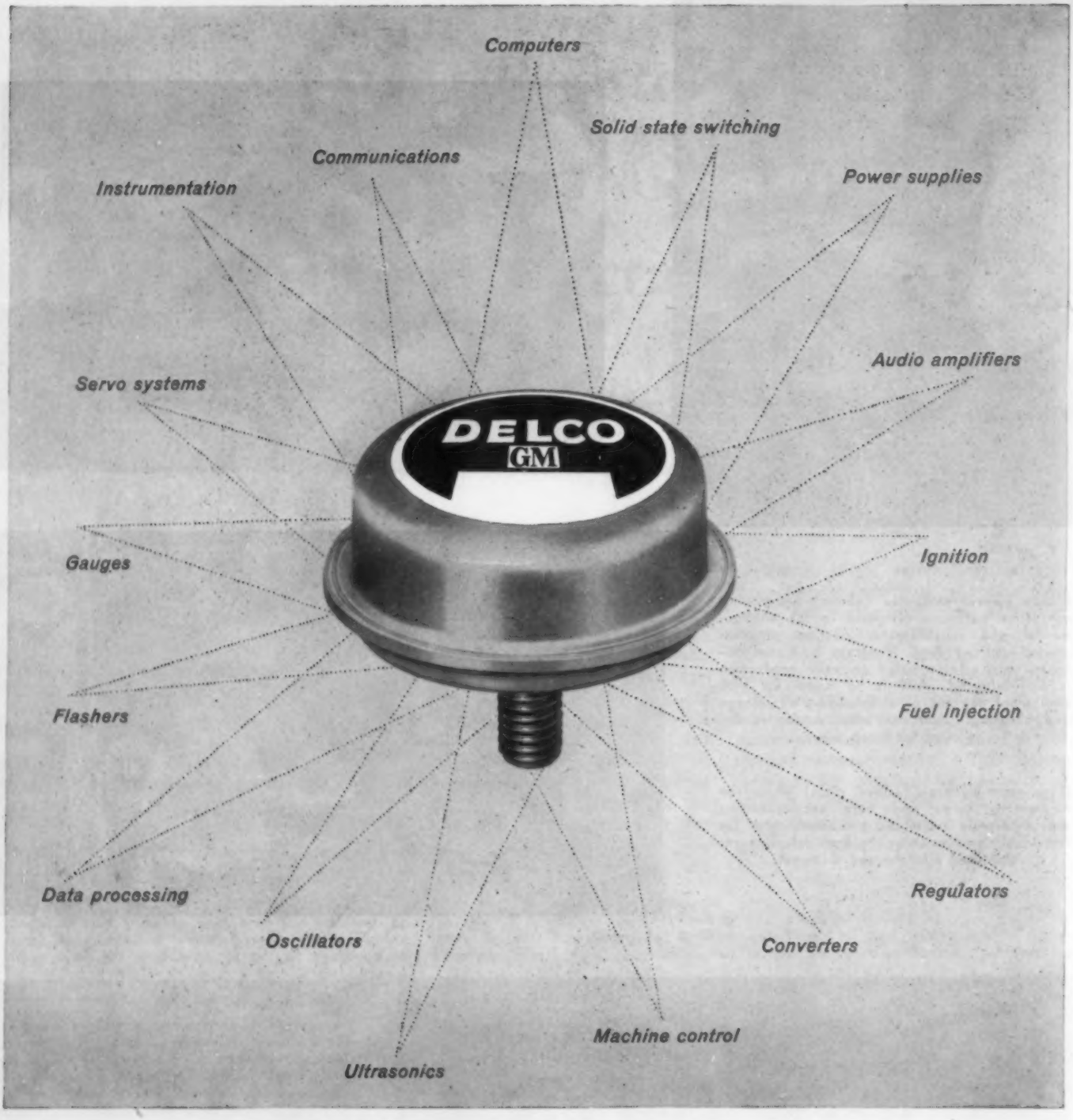
Missile control computer (above) undergoing exhaustive performance check in the environmental and reliability engineering program carried out by Ford. Program is a continuing parallel effort carried on while production is uninterrupted. Aim is to come up with equipment capable of withstanding all storage and handling conditions when missile is deployed for troop use.

Gyro assembly area (above, right) where the air-bearing gyros and gyro accelerometers are completely assembled and then tested for individual performance before assembly to stabilized platform and shipment.



In the photo above, test engineers are making drift-rate checks on air-bearing accelerometers. These units, an outgrowth of accelerometers used on the V-2 missile, are extremely sensitive due to the almost frictionless air bearing around their precession axes. Meticulous performance testing and calibration are necessary prior to assembly on the missile stabilized platform.

To the left, a JUPITER missile inverter, used to provide ac power for the guidance and control system, is undergoing vibration and acceleration testing. All components of the inertial guidance system are subjected to environmental testing which duplicates conditions of actual missile flight. Other environmental facilities include heat, cold, sand and dust chambers, and shock testers. Inverter shown here must deliver ac power with close regulation of voltage and frequency while being cycled through these tests. Fluctuations in performance could have serious effects on the guidance and control system while the missile is in flight.



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Tracking Long-range Missiles

charts simplify choice of tracking stations

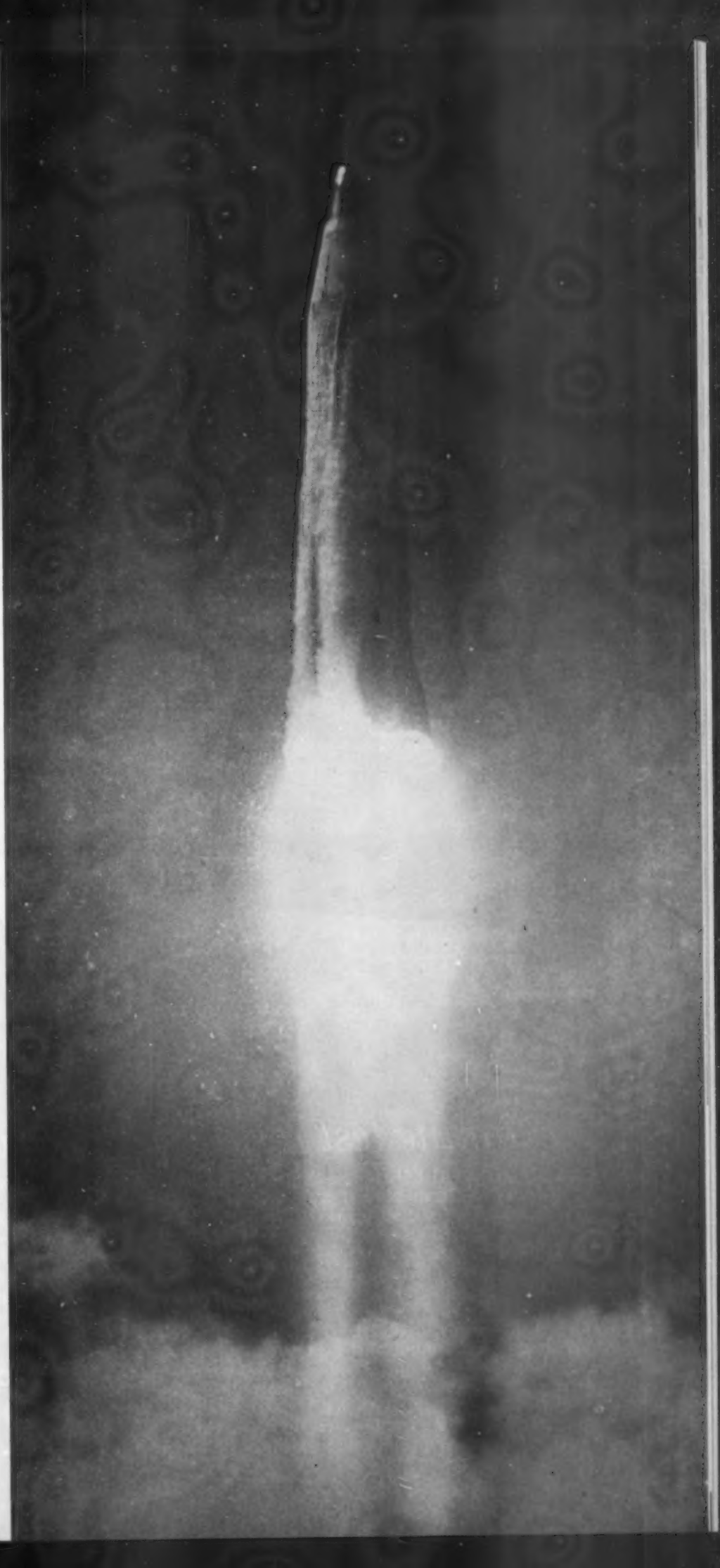
by **Raymond M. Nolan**

ON THE 10TH of January, the *Atlas* intercontinental ballistic missile was fired for the second successful time in four attempts. The Department of Defense announced that the latest test, like the previous successful one, was one of limited range and that the missile had landed in the preselected impact area. "Limited range" in these cases probably means that tests of the rocket-booster mechanism are being conducted as the initial part of the range testing program.

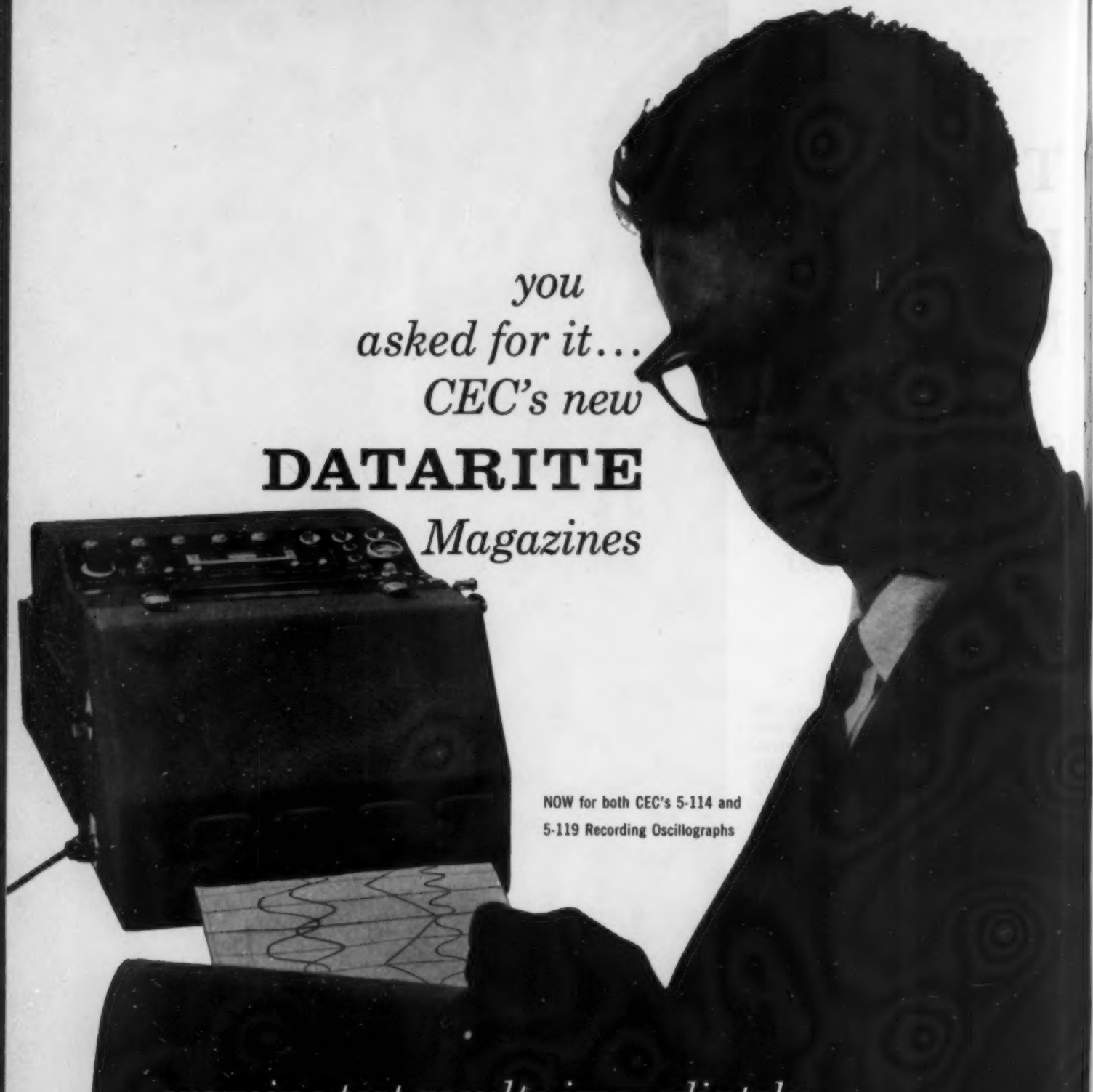
One element of the test program, important not only in the early phases, but throughout the entire testing cycle, is the precise determination of missile position at any given instant of flight. This is accomplished, of course, by elaborate radio tracking facilities at the launching site and at the various downrange tracking sites strung out over the South Atlantic Ocean.

Long-range missiles of the IRBM and ICBM types, because they travel at such tremendous speeds and go such extended distances beyond the horizon, require truly accurate and precise radio tracking equipment to find the missiles in the air and monitor their flight paths.

A critical consideration in designing and installing radio tracking equipment such as that used at the



Atlas ICBM. Range testing program now in progress requires precise determination of position during flight. Aids to tracking simplify problem at high altitudes.



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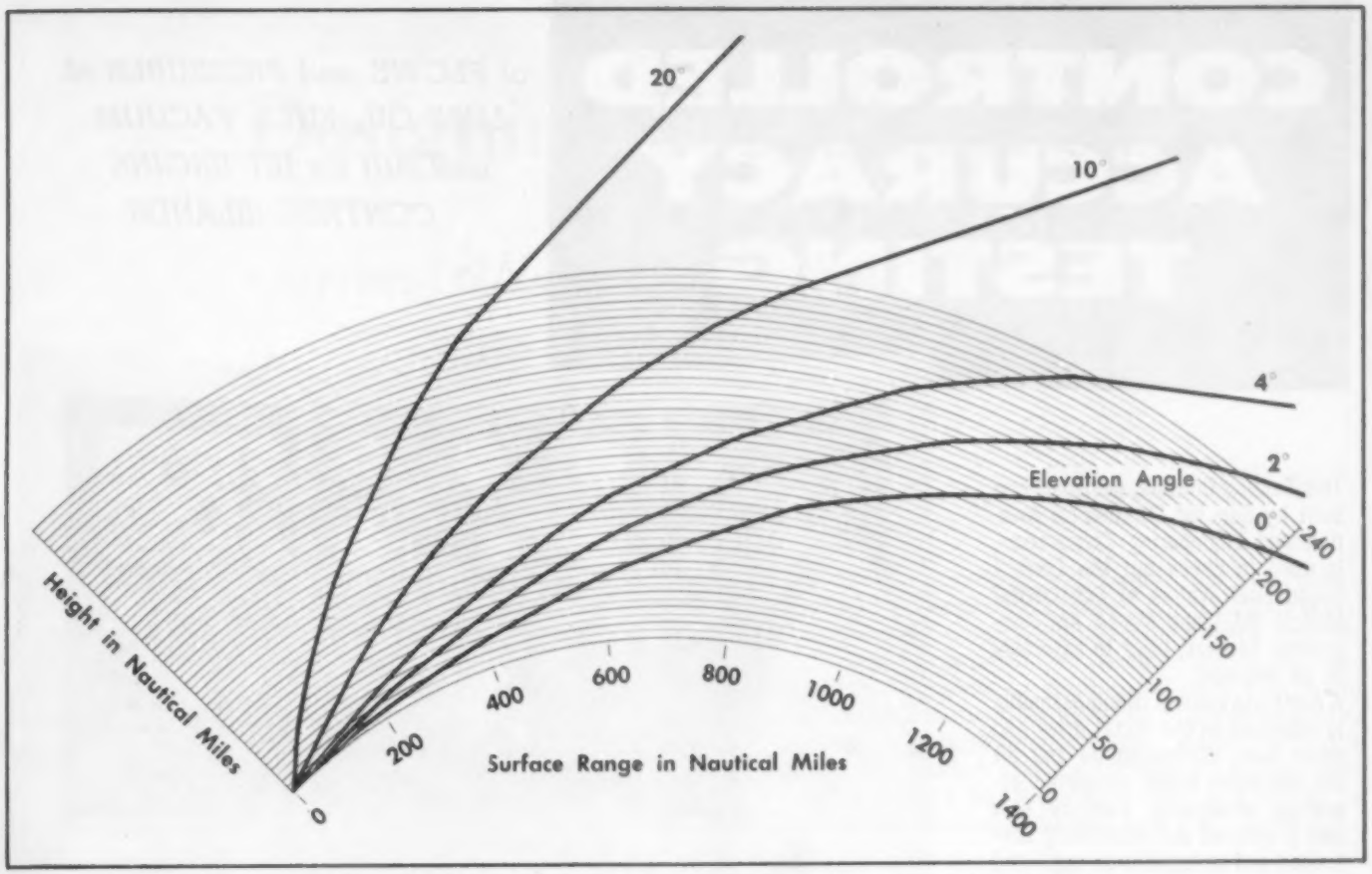

Fig. Relationship between distance radio waves will travel to antenna elevation angle.

U.S. Air Force Missile Test Center, Cape Canaveral, Fla., is the exact range or distance that radio waves will travel and still accurately report precise position information back to the launching area.

Most electronic missile-tracking systems are limited in range to what is commonly called "radio line-of-sight." This distance, which is slightly longer than visual line-of-sight because waves are refracted in a different manner in the upper atmosphere than light waves, tends to vary in accordance with the frequency of the radio waves.

Fig. 1 shows the relationship of the distance that radio waves will travel to the elevation angle of the radio antenna. The atmosphere, for this representation, is divided into finite bands of bending characteristics dependent on the altitude above the earth's surface. The interesting factor to note is that the paths of the radio signals are not straight lines, as is usually assumed for conventional radio applications.

Prior to the advent of long-range missiles, which must be tracked by accurate systems, not too much attention was paid to these bending characteristics of VHF and higher frequency signals: for ground communication purposes, the atmospheric effects of high-altitude refracting phenomena are not too pertinent. However, with missiles traveling to 200 and more miles in altitude, these factors take on new importance.

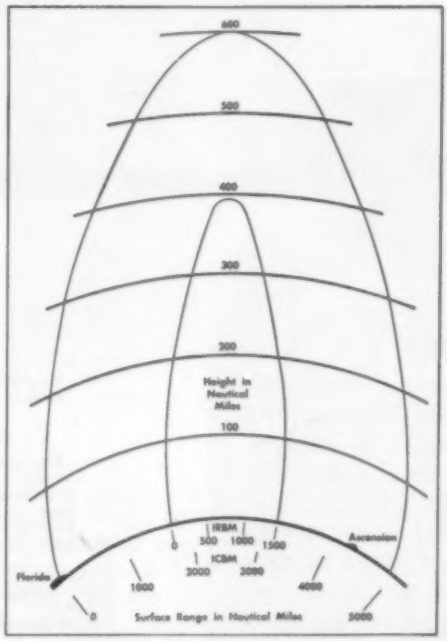

Fig. 2—IRBM/ICBM altitudes and ranges.

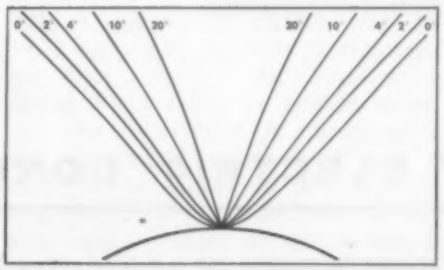

Fig. 3—Radio wavepaths at various angles.

To provide an accurate basis for precise measurements, some graphical means are required for determining the distance VHF radio signals will travel, depending on their frequency and the maximum height they are expected to attain. Figs. 1-3 show some graphical aids to missile tracking by radio instrumentation developed by Cubic Corp., San Diego, Calif. in conjunction with electronic tracking equipment manufactured by that company for the U.S. Air Force.

Fig. 2 shows the initial and final major missile-tracking ground installations currently manned by the Air Force and its contractors for the purpose of monitoring the flights of long-range missiles.

Fig. 3 contains distance data in the form of curved lines which correspond to paths of radio waves at various frequencies and at various elevation angles to the earth's surface.

Using Fig. 2 as an overlay and viewing it simultaneously with Fig. 3 simplifies the preliminary ground-tracking arrangements for a long-range missile flight. To choose the number of ground stations needed to track a forthcoming flight and determine the optimum islands and other installations on which to place the ground radio equipment becomes no more than a routine operation.★

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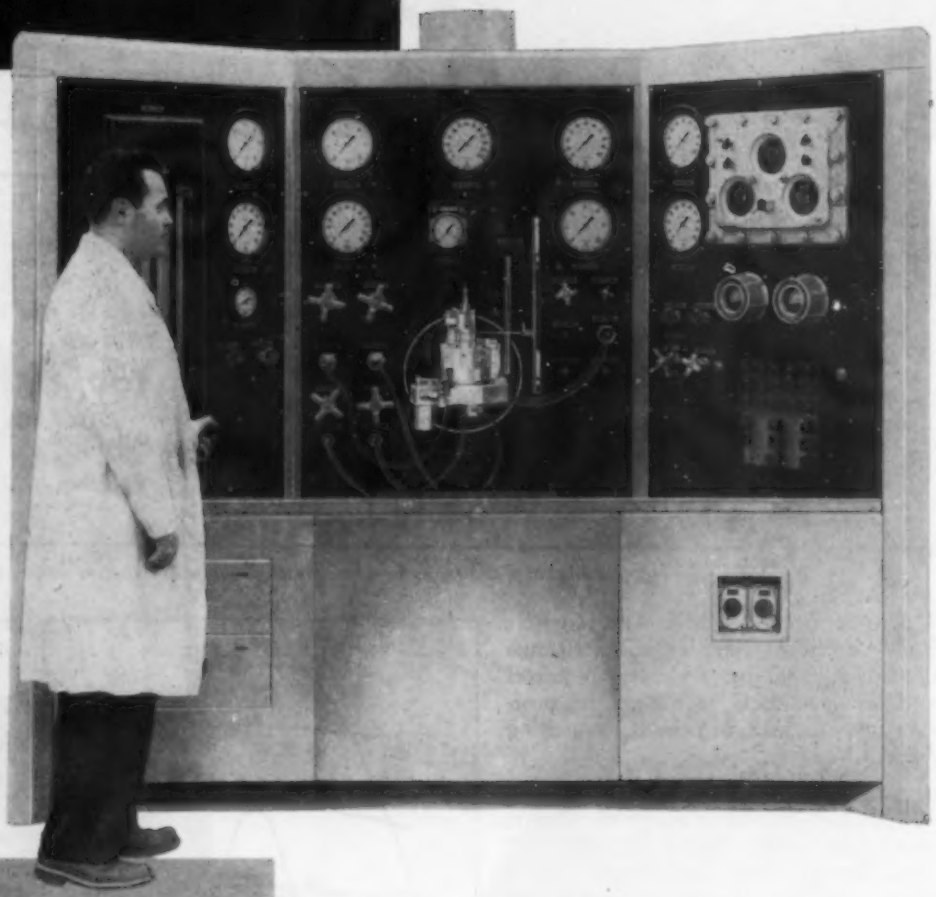

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Designing for Simplicity

extreme reliability the goal in electronic design

by Edward S. Shepard

THE TRANSMISSION of information or data plays an increasingly important role in man's conquest of his environment. The development of means for transmitting data between distant objects—telemetering—is as significant to modern technology as was the formulation of spoken or written language to earlier progress. Telemetering is generally defined as the indicating, recording or integrating of a quantity at a distance by electrical translating means. The main emphasis here is on electronic data transmission with a single component, the voltage-controlled oscillator (VCO), the particular subject.

In May 1957, the Shepard Instrument Co., at the request of one of the leading missile centers, began development work on a missile telemetering device known as a voltage-controlled oscillator, one of the more essential portions of a missile data transmission system in the sensing of signal information as a function of the original physical measured quantity. The need to know what is happening to a missile under test has opened a whole new field of telemetering where delicate electronic components cannot withstand the environment and do not perform their function with an acceptable degree of reliability.

Lack of simplicity in engineering design is believed to be one of the most significant causes of unreliability of military electronic equipment today. Because of this, a simple, rugged and reliable VCO was the design objective.

The entire program was aimed at breaking through the frontiers of transistorized telemetry and toward the development of a thoroughly reliable unit which would satisfy all customer design criteria.

The author is chief engineer, Shepard Instrument Co., Phoenix, Ariz.

Unhampered by traditional thinking, Shepard engineers developed a new and entirely different concept in telemetering where simplification is considered an advancement over presently available equipment. This simplification required the development of components which were both small and strong.

It is fortunate that the terms "small" and "strong" go together, weight being proportional to the cube of the linear dimension, while the supporting area is proportional to the square of the linear dimension. Thus, reduction in size by a factor of 10 results in an object the strength of which is increased by 10 under acceleration. This is one of the reasons why the VCO can be constructed to withstand the high vibratory and accelerating forces which occur in missiles today.

The VCO itself is transistorized and completely encapsulated into a final plug-in component that is moisture proof, has no adjustments of any kind, and is rugged enough so that it can be fired against a cement wall without impairment to its operating characteristics. Fig. 1 shows the VCO before and after encapsulation and packaging.

Operational requirements severely restricted the number of circuit elements or component parts that could be used to meet the required operating specifications. This meant that the usual practice of adding circuitry had to be eliminated and replaced by a design technique based on simplicity—one that required considerable thought by the designer on the exact and proportionate relationship between various circuit elements. It was this relationship that provided the reliability and accurate performance of these new telemetering devices.

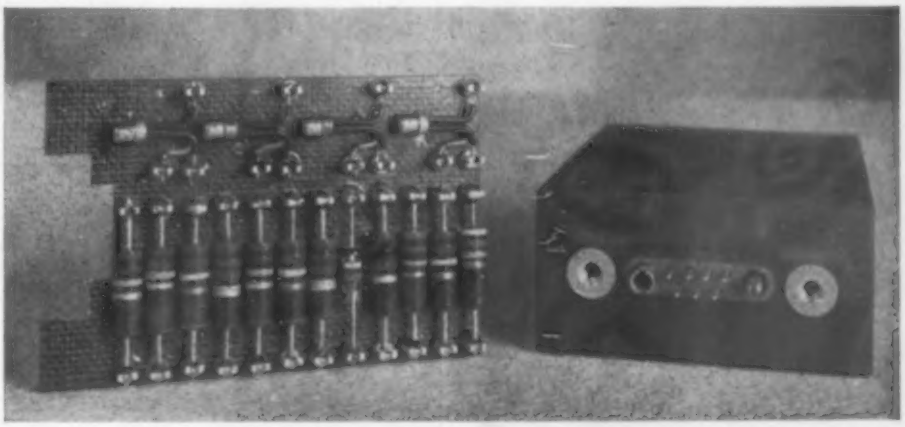

Fig. 1—Block diagram of typical application for a voltage-controlled oscillator and equivalent oscillator tuned circuit with dc input.

A new method of controlling an oscillator frequency electrically has been made possible by the characteristics of the transistor. Fig. 2 is a schematic diagram of the encapsulated transistorized VCO.

In this application, the voltage across the tuned circuit is 90° out of phase with the current in the loop. During alternating half-cycles, the circulating tank current passes through the emmiter-to-base diode of a modu-

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lator transistor, and during the remaining half-cycles, passes through a diode. A dc control-signal current is fed into the input terminals and biases the emitter of the modulator transistor by varying amounts.

The collector of the modulating transistor will then supply reactive current to the tuned circuit, causing a shift in the oscillator which, though primarily designed for use in FM/FM telemetering transmission systems, finds useful application in other mobile or fixed ground installations. Its function is to convert intelligence in the form of a variable voltage to a frequency-modulated subcarrier signal in one of the standard IRIG telemetering frequency channels. This frequency-modulated output signal may be transmitted or, if desired, mixed with the intelligence-carrying outputs of other subcarrier oscillators and then transmitted to remote receiver locations by wire, radio or microwave length.

This tiny solid-state device has many applications in military and industrial telemetering such as the measurement of ac or dc voltages of varying amplitudes. These voltages may be either the direct stimulus which is to be measured as in thermocouples or the output of a voltage-producing pick-up such as vibration pickups or potentiometer-type instruments. Other input transducers include the unbonded

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HUMIDITY—This completely encapsulated VCO is moistureproof and will meet the applicable specifications, when subjected to 95% R-H for 6 hours at 50°C.
SHOCK—Designed to withstand 500 g impact shock.
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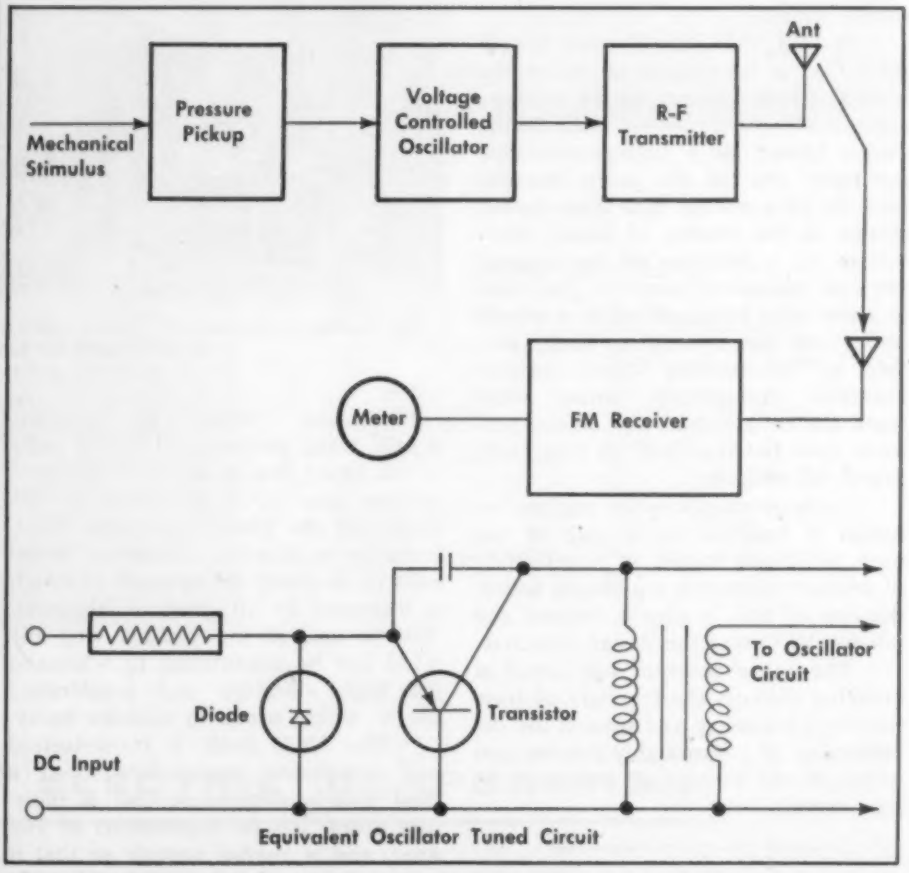

Fig. 2—Voltage-controlled oscillator before encapsulation and, on right, after encapsulated in epon resin and packaged ready for use.

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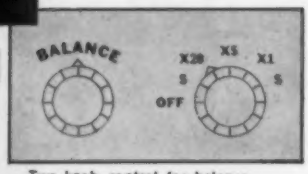

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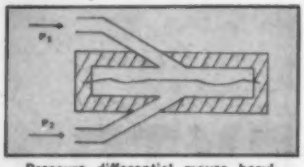

Pressure differential moves beryllium-copper diaphragm.

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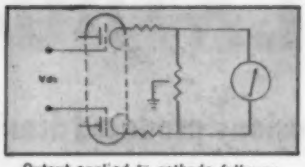
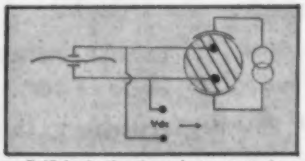


Output applied to cathode follower to drive meter.



T-42 Ionization transducer converts motion into electrical signal.

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strain-gauge pressure pickup and the linear differential transformer (LDT) pickup.

The linearity of the VCO is in the order of .05 per cent of the design bandwidth and the frequency stability is well within .1 per cent of the center frequency. The unit has a self-contained band-pass filter and weighs slightly over three ounces. Power requirements are 2.5 volts dc at 5 milliamperes.

These are the details and design considerations for a telemetering information oscillator employing transistors in circuits of advanced design where small physical size and weight are important. Miniaturization has been carried to an ultimate degree, but has still been kept within practical limits.

The encapsulation techniques which have been developed are largely responsible for the extremely rugged and shock-resistant package.

Transistors, one of the great developments in the field of electronics, have considerable advantage over the vacuum tube with respect to space and power requirements and, in many applications, will give superior performance. Transistors are gaining wide acceptance in nearly every phase of electronic design and can be expected to provide numerous new and improved packages, not only in applications such as the one described here, but for other fields of endeavor as well. The use of transistors, coupled with a real effort for the utmost simplicity in design, points to a new level of reliability in the field of electronics.

Since the effects of reliability are felt both in equipment costs and military operational status, consideration of simplicity and ruggedness in early design phases makes it possible to achieve the ultimate goal of a reliability engineer—a low, measurable index of reliability.

The Department of Defense recently released an advance draft of a reliability assurance program of guided missiles. This program calls for regular determination of reliability during all phases of missile development.

Even though the program states that progress has been good to date, it goes on to say that, with the use of present procedures, projects have been known to last from five to 10 years and cost as much as $500 million before it was discovered that the system being developed was inherently unreliable.

The use of the Shepard theory that simplification results in advanced design in electronics research and development programs can be expected to result in improved system reliability.★

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Propulsion Engineering

by Alfred J. Zaehringer

Project "Bear" may use liquid hydrogen. An Air Force propulsion program with liquid hydrogen is reported under way at Painesville, Ohio (a pilot plant), and Cape Canaveral, Fla. (large scale). Air Products and Linde are reported to have a $100-million contract for the "Bear" series of fuels. The hydrogen work may stem from NBS cryogenic lab at Boulder, Colo. NBS makes handling easier by converting hydrogen into the more stable para form.

•

Hydrocarbon ramjet fuels are still good. APL has looked at the fuel field for BuOrd. Low cost, high availability, good handling, good performance and favorable exhaust products still are on the side of conventional hydrocarbon compounds. High-energy fuels can only be justified for special cases (like highest thrust or low fuel expenditure) or under unusual operating conditions, namely high altitudes. The following organics look good for unusual flight regimes: acetylene, carbon disulfide, ethylene oxide, or propylene oxide. It is pointed out that, with the exception of the boron hydrides and acetylene, no compounds seem to offer better fuel economy over the hydrocarbons.

•

Solid fuel ramjet offers simplicity and reliability. This was the conclusion of Experiment, Inc. which flew such an engine in supersonic flight in January 1952. Air specific impulse using magnesium is tops at about 300 seconds; aluminum has a top of about 220 seconds while hydrocarbon fuels drop off at under 180 seconds. Others reported doing work with solid ramjets are: Air Force, Applied Physics Lab, American Rocket Co., Bureau of Mines, Continental Aviation and Engineering Corp., NACA, Reynolds Metals Co., University of Detroit, NOTS, and BuOrd.

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Helium or neon free radicals may give high performance. Metastable condition for noble gases is a result of electron in outer orbit moving to a higher energy position. A 10 mol per cent of excited helium in inert gas diluent might give an impulse of 500 seconds, say GE researchers doing free radical work at NBS. Metastable neon, though giving lower performance, might be storable indefinitely at ultralow temperatures—the half life ranges from 25 seconds at 10°K to years at 5°K.

Atomic rocket engine will be large. Rocketdyne calculations reveal a reactor diameter of three feet and a length of six feet for a 100,000-pound-thrust, hydrogen working fluid nuclear engine. This does not include control rods, reflector, pressure walls, supports, etc. The maximum reactor temperature would be 4000°F with a mass flow of 127 lbs./sec. hydrogen (at 800 psi) to give an I_{sp} of 790 seconds at 3600°F hydrogen temperature.

•

Shielding an atomic rocket can be done. So say Ehricke and other advocates of manned space flight at Convair. Using hydrogen as propellant and shielding, the crew would be placed about 250 feet from the reactor. The hydrogen shielding column will decrease to about 92 feet during the last power phase of an Earth-Mars and return rocket trip. During this time the crew would receive 12 rem gamma dosage all of which occur at minimum shielding. Cosmic ray dosage might be higher, something like 15 rem/year. Humans can take a career dose of 100 to 500 rem. It is suggested that such nuclear systems might be available some 10 to 15 years from now and would offer definite advantages over either chemical or ionic systems.

Pattern check for the first stage drive gear for the Sikorsky S-58 Helicopter. The large gear is concave, cannot be ground and must be carburized and hardened with sufficient freedom from distortion to maintain pattern and tolerances expected only of master gears.

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By Norman L. Baker

Polaris Pioneers Future Ballistic Missile Design

The missile that may soon create a major shift in ballistic missile design concepts soared skyward last month from Cape Canaveral, Fla. This flight of a *Polaris* fleet ballistic missile test vehicle was the first successful launching announced by the Navy. At least two other test vehicles have been fired from the Cape in past months and reported highly successful.

This radically new weapon system is the result of several major breakthroughs in development of solid fuels, motor design and controlled burning. Its range is that of the *Thor* and *Jupiter*, yet its advantages over the two are outstanding.

The most outstanding feature is the simplicity and reliability of the propulsion system. It will operate on a ready-to-fire status around the clock. The liquid-propellant *Thors* and *Jupiters* must be loaded with liquid oxygen within minutes of a firing. Some reports have stated these IRBMs could be on a 24-hour alert and ready for firing after a 15-minute countdown but this is true only if they are kept loaded and checked out. A continual operation of "topping-off" the liquid oxygen supply would be required to offset the rapid evaporation of this low-boiling-point oxidizer. The cost of such an operation would be prohibitive, to say the least.

Land-based Version

A land-based version of the *Polaris* for the Air Force is currently under study. Although the *Polaris* is, in its present configuration, adaptable to land operation, the Air Force will probably look to the newly formed Astrodyne Corp. for development of the missile system.

The solid-propellant ballistic missile is extremely mobile and requires very little ground support and checkout equipment. The ground support equipment necessary for liquid-fueled missiles is the biggest headache of logistic planners. Launching a ballistic missile that rises with an acceleration of less than 2 g's—the rate of acceleration of the *Atlas*, *Thor* and *Jupiter*—can be a very tricky or impossible business during high-wind conditions. A weapon capable of instant retaliation must not be so limited by weather conditions. High acceleration at launch is another factor that makes the *Polaris* a much-sought-after weapon system.

Polaris is a two-stage vehicle only 45-50 feet long, compared with the 60-foot *Thors* and *Jupiters* and is a few inches less in diameter than either of them. It will utilize a smaller nuclear package, developed since the *Thor* and *Jupiter* designs were frozen. Destruction potential of the warhead will be the same.

Guidance system for the *Polaris* has been reduced to a compact 150 to 200 pounds from the *Jupiter* system of 250 to 300 pounds and *Thor* system of 650 to 700 pounds. Developed by GE, the system will be extremely rugged, to withstand the high acceleration encountered throughout the powered flight.

Propellant Breakthrough

Thiokol Chemical pioneered the propulsion system breakthrough that has made the *Polaris* possible. The initial six first- and second-stage test-vehicle motors were developed and tested by Thiokol. The first flight tests at Cape Canaveral are reported to have used the Thiokol motors. Meanwhile, Aerojet-General has delivered the first development motors to Lockheed, the prime contractor for the *Polaris* system.

The solid-propellant rocket was long considered undesirable and impractical for long-range rockets because of high motor weight, uneven burning and the inability to control the missile's flight path in the thin upper atmosphere. Motor casing thickness has been reduced to approximately ¼ inch while thicknesses of 1/10 inch appear promising. Uneven burning no longer plagues solid-fuel motor developers.

Directional control for the *Polaris* is achieved by confining the combustion of the motor within a spherical chamber and directing the thrust through four small nozzles exhausting to the rear and four "venting" nozzles that exhaust against the direction of travel. This unique nozzle arrangement provides control in pitch and yaw and assures separation of the warhead at the instant the required velocity is attained.

Operational by 1960

Polaris, as a Navy weapon, will not be an operational system until it is combined with its launching platform, the nuclear submarine. The missile is two years ahead of schedule—plans now call for operational readiness by 1960 instead of the original 1962 date. To serve as an effective deterrent weapon, officials point out, at least 100 *Polaris*-equipped submarines, positioned in strategic locations, will be needed.

A supplemental defense appropriation will call for funds for the first three *Polaris* submarines. The Navy, meanwhile, is considering the request of an additional appropriation for six more of the ballistic missile submarines. R. Admiral W. F. Raborn recently told Congress that he has been granted unlimited funds for the *Polaris* program and was moving as quickly as possible on development of the missile and the submarine carrier.

Navy officials have emphasized the *Polaris* will be fully developed and ready for mass production long before it can be used effectively. Navy shipbuilders are confident that an acceleration of the submarine building program could make the nuclear missile carriers available 18 months from the date the keels are laid. An accelerated program initiated immediately would make the submarines available at the same time the missiles are perfected and ordered into production. Sen. Henry Jackson (D-Wash.) has expressed concern over the lag in the program. He said the actual number of missile submarines planned is "shockingly small."

Meanwhile, the Air Force may request that it be included within its arsenal before the Navy has enough submarines to deploy them effectively.

Cornell Investigates Weightlessness

Cornell Aeronautical Laboratory has recommended to the Air Force experiments in which both a monkey and rat would be sent aloft in a capsule enclosed within the nose of a rocket to study animal behavior under conditions of weightlessness.

Under a contract with the space biology branch of ARDC's Holloman Air Force Missile Development Center, CAL has completed a study to determine what type experiments on animals in space capsules might provide the best clue to human reactions during the state of weightlessness as caused by lack of gravity and other external forces in space.

In its study, CAL reviewed various animal experiments that could be expected to detect disturbances in cognition, orientation and concentration during exposure to weightlessness. Consideration was given to weight and space limitations inherent in rocket experiments.

The purpose of the study was to choose suitable animals and appropriate tests, as well as to specify realistic engineering details on how to investigate the efficiency of intellectual functions (as opposed to physiological reactions) of man during the weightless state. As a result of the study CAL recommended that a monkey and a rat enclosed in the same capsule would give the most satisfactory results.

In order to simulate human "decision" behavior, the animals would be subjected to stimuli that, under normal conditions, are known to cause a particular reaction. For example, such animals as rats will repeatedly perform a responsive action which is followed by a pleasant sensation. This is referred to as "self-stimulation."

Animals also are known to behave in a manner referred to as "double-avoidance discrimination." For example, an animal can be trained to respond to a cue so that it anticipates and thereby avoids a particular annoyance. It also can be trained to discriminate or sense the difference in degree of the cues.

Thus, a monkey can be trained to make the avoidance response to a weak light and not to a strong one, to a flickering light and not to a steady one, to a buzzer but not to a pure tone. Response to two separate stimuli is described as "double-avoidance discrimination"—the simian can be trained to pull a chain when a light comes on and to press a pedal when a buzzer sounds.

The study by Cornell Laboratory recommends the use of the self-stimulation technique for the rat and the avoidance procedure for the monkey in order to provide an indication of the effectiveness of both positive and negative drives during weightlessness. The difference in the two animals themselves also may prove of help in interpreting results.

The more complex of the experimental arrangements would deal with the monkey. It would be strapped in place in the capsule with its arms attached to two levers so that they can move either to the right or left. The experiment would be arranged so that the monkey, to avoid some annoyance, will move the right hand lever a certain distance to the right and the left hand lever to the left.

Directly in front of the monkey two lights—red and green—would be located at eye level. These would light up at random and provide the monkey the cues to avoid the annoyance.

Whether and to what degree the animals can retain their known capacities during the weightless state is the prime question. The behavior of both animals would be recorded by motion pictures as well as by special telemetering equipment.

The work on this project is being done by the human factors section of the Laboratory's vehicle dynamics department in consultation with Prof. B. Richard Bugelski, Psychology Department, University of Buffalo.

Regulus II Ordered into Production

A $26-million contract for continued evaluation and production of the submarine-launched *Regulus* II guided missile has been awarded to Chance Vought Aircraft.

The contract, which puts the nuclear-warhead-carrying missile into quantity production, also contains provisions for spare parts and special support equipment estimated at an additional $7.5 million. An undisclosed number of both test and tactical versions of the missile will be produced with the Navy funds. Latest award brings the company's backlog of unfilled orders to approximately $675 million.

The 1000-mile-plus-range *Regulus* II, in the final stages of an accelerated test program at Edwards Air Force Base, Calif., will be launched from conventional and nuclear-powered submarines now under construction. Three U.S. submarines—the nuclear USS *Halibut* and the conventionally powered USS *Grayback* and USS *Growler*—are being built to fire the *Regulus* II. Conventional subs could also be converted as *Regulus* II missile carriers. In an emergency, the missile could be fired from mobile launchers aboard any ship big enough to carry it, including mothballed baby carriers of World War II vintage.

Test and training versions of the *Regulus* II had as standard equipment a landing gear which enabled crews to launch the missiles and recover them for additional cost-saving reflight.

First flight of the *Regulus* II was in May 1956. Guided Missile Unit 55, the first Navy unit assigned to handle the missile when it becomes operational, is already organized and in training.

Moon Guidance Easier Than 5000 Mile ICBM?

Dr. Donald B. Duncan, scientist for the Autonetics division of North American Aviation, recently told the Institute of Navigation's western members meeting that shooting for the moon is a simpler missile guidance problem than hitting a target 5000 miles away with an ICBM. However, he stated that striking the moon's surface within a 100-mile target, or establishing an orbit around the moon with the same accuracy, is a problem comparable with successful impact of an ICBM at destination.

Additional refinement of present day guidance systems and extension of know-how will be essential to realize this accuracy goal due to the differences in the two systems, Dr. Duncan said.

The earthbound missile needs guidance to control speed at the end of the boost trajectory. Once pointed in the right direction and controlled while under power, the missile is on its own in unpowered flight beyond the atmosphere, re-entering on a ballistic path to the target.

A missile to the moon would require guidance not only during the boost phase but through every stage of the journey.

"For initial boost phase of the space vehicle," Dr. Duncan said, "inertial guidance appears to have the important advantage over other types in that the same equipment can be profitably used in later phases of flight."

Guidance for interplanetary ballistic missiles would be about the same for earthbound ballistic missiles, although more accuracy is needed for the former. There are several promising possibilities for guiding an interplanetary cruise missile. One, a lead-pursuit-type intercept guidance, appears particularly simple and easy to mechanize, although additional investigation is required in this field before feasibility can be determined.

contract report

Trends

The Nation Faces a Boom in more ways than one. If you're in the missile business, now is the time to hit the road and do some real hard selling. President Eisenhower is asking Congress for another $4 billion in defense spending. Congress may well hike that total. A respectable portion will go directly into missile procurement. Furthermore, these contracts will have top priority—meaning full overtime allowances, first call on materials and top personnel services. In the next 18 months, the new era really gets into high gear. To repeat: the time to sell is now while contracts are flooding out.

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Current Events Give a View of the Future: An early December estimate showed planned obligations (contracting) for fiscal year 1958 for missile research development and production totaling over $4.5 billion, with surface-to-surface total of $2.1 billion, of which $1.928 billion is for *Snark, Thor, Jupiter, Titan, Atlas* and *Polaris*. The official administration budget substantiates these estimates. And even these totals will be increased. Note recent blank check given *Polaris* speedup, plus supplemental appropriation request, plus Congress additions still to come. Electronics figures cited by James D. Secrest, executive vice president of the Electronics Industries Association, state, for example, that military electronics procurement has risen from $2.7 billion in 1956 to $3.5 billion in 1957; that the rise will be even more rapid in 1958; and that increased missile procurement and space flight exploration will hike present 23 per cent of current military procurement dollars going to electronics.

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Developments in Contract Procedures: Armed Services Procurement Regulations have been amended to assure a contractor's investment in work-in-process cost-type contracts. See par. D to ASPR 3-404.3 . . . All new cost-reimbursement contracts of $250,000 or more will be subject to new 80 per cent payment limitation for work in process. It's in November DOD Directive No. 7800.6 . . . Pentagon DOD Instruction No. 4155.9 explains policy on inspecting subcontracted supplies.

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Contract Renegotiation Act Expires December 31, 1958. It will be renewed but with changes. If you want to lobby for your version, now's the time to do it. Rep. Wm. E. Hess (R-Ohio), for example, wants Renegotiation Board's laws revised—doesn't like fact that Board in some cases is four years behind in profit redetermination or fact that now the national Board can over-rule regional offices either up or down—figures it makes corporate planning a bit difficult.

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Defense Contracting Procedures, as a matter of fact, will be gone over from many directions. House Armed Services Investigations Subcommittee wants contracting procedures tightened up, secrecy lifted from negotiated contracts, and elimination of 1950 Korean Emergency Proclamation allowing exceptions to advertised bidding. Strategic Industries Association has issued an eight-point program, "The Government's Facility Fallacy," aimed at securing "maximum production at lowest cost by the free operation of competition without benefit of subsidy to small firms or large." Program includes amendment of Renegotiation Act to provide incentives for cost savings through efficient subcontracting; also revision of system whereby Government leases tools and facilities at under the going rate. At the same time National Security Industrial Association has offered a seven-point opposition to Defense-Department-proposed revision to Section 15 (re: allowable costs) of Armed Services Procurement Regulations. And DOD has promised to make it easier and quicker for priorities to be assigned to new weapons projects.

Awards

For Falcon: Hughes Aircraft Company's Tucson Division has been awarded a contract for $19,278,275 for production of advanced *Falcons*, GAR-3 and GAR-4.

For Regulus II: Chance Vought Aircraft has received two contracts on *Regulus* II—one in the amount of $26 million for continued evaluation and production, and another for spare parts and special support equipment.

For Jupiter and Redstone: Chrysler Corp. has been awarded a $30-million contract for assembly-line production of *Jupiter* IRBMs and a $21.8-million contract for additional *Redstones*.

Hughes Aircraft Company has received a $21,188,717 contract from Air Force for additional production of airborne control and weapons systems for advanced all-weather jet interceptors.

Flight Refueling Inc., has received a contract from **Martin-Denver** for engineering consulting services on *Titan* fuel handling; no amount was stated.

United Control Corp., has received a contract from **Douglas Aircraft Co.** to supply propellant-loading computor for fully automatic fueling of *Thor* IRBM.

Air Products Inc. and **Linde Co.** are reported to have a $100-million contract for the "Big Bear" series of fuels. The AF propulsion program with liquid hydrogen is understood to be well underway. The hydrogen work may stem from the National Bureau of Standards Cryogenic Laboratory at Boulder, Colorado.

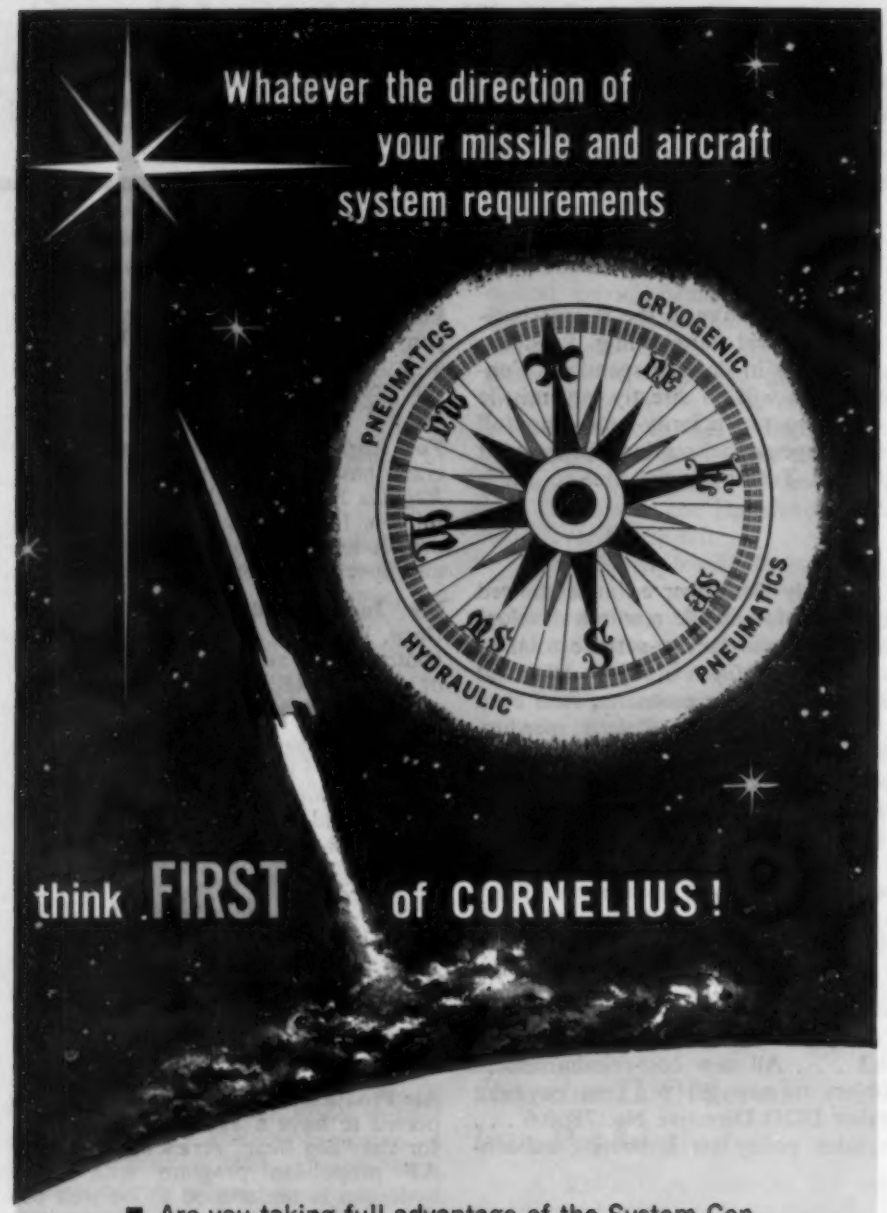
Cornell Aeronautical Laboratory has been awarded a two-year Army contract to improve systems of surveillance of a battlefield by radar, infrared, sonic, meteorological, drone reconnaissance, photography and television.

Systems Development Corp., Santa Monica, Calif., a new nonprofit company, is taking over a $20-million contract from **RAND Corp.** to provide professional technical services for the Air Defense Command. Originally the contract was made with the **System Development Division of RAND.**

Northrop Aircraft, Inc., expects more than $130 million in new USAF contracts before the end of the year.

A $5,009,000 contract for MA-8 fire-control systems for the Republic F-105 has been awarded by USAF to **General Electric's Light Military Electronic Equipment Department,** Johnson City, N.Y.

Other missile contracts during the month: Tidewater Oil Co., $539,648 for rocket



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Contract Awards

fuel . . . **Aerojet-General Corp.,** $146,450 for research studies on positive ion surface emission for ion propulsion systems . . . **Bell Aircraft Corp.,** $93,216 for research observation of burning propellants in rocket engines . . . **Atlantic Research Corp.,** $41,168 for continuation of research on solid-propellant combustion . . . **Union Oil Co. of Calif.,** $276,644 for RP1 rocket fuel . . . **Rohm & Haas Co.,** $1,590,001 for continued research and development in the field of solid-propellant rocketry and operation of pilot lines and equipment . . . **National Cooler Div., W. F. Ryan Corp.,** $183,750 for propellant mixture.

Paul Smith Construction Co., $561,141 for construction of General Electric guidance facilities, Mod. III, and $274,570 for construction of additions and modifications to complex 17 and 18, AFMTC, Patrick AFB . . . **Electronic Engineering Co. of Calif.,** $41,400 increase in funds . . . **The Regents of the University of Minnesota,** $53,317 for continuation of research on flame stabilization of bluff bodies at high speed and large Reynolds numbers . . . **Grand Central Rocket Corp.,** $53,943 for propellant development.

Marks Oxygen Co., Inc., $126,835 for liquid oxygen . . . **Bendix Aviation Corp.,** $57,860 for technical instruction in operation and servicing of liquid oxygen systems . . . **Westvaco Division of Food Machinery and Chemical Corp.,** $38,157 for rocket propellant . . . **Sterling Precision Corp.,** $30,950 increase in funds awarded by Patrick AFMTC . . . **Douglas Aircraft Co.,** $308,588 for repair parts for *Nike* system . . . **Motorola Inc.,** $150,000 for development of engineering studies, analysis and design of airborne instrumentation.

North American Aviation, Inc., $44,557 for airborne digital computing techniques study . . . **Westinghouse Electric Corp.,** $174,530 increase in funds awarded by Patrick AFMTC . . . **Empire Products Sales Corp.,** $32,884 for field intensity meter . . . **Western Electric Co.,** $55,189 for *Nike* spare parts and components . . . **Perkin-Elmer Corp.,** $72,000 for intermediate-range theodolite . . . **Pavarini Construction Co., Inc.,** and **D. L. Prager & Co.,** $1,455,000 for station facilities at Antigua Island, BWI, for AFMTC . . . **C. H. Leavell & Co.,** $1,295,035 for ABMA facilities at White Sands Proving Ground, N. Mex.

Western Electric Co., Inc., N.Y., $5,686,481 for research and development of *Nike-Zeus (Nike* II) guided missile system . . . **Gilfillan Bros., Inc.,** $567,127 for furnishing and delivering of depot replenishment repair parts for *Corporal* missile system . . . **Firestone Tire & Rubber Co.,** $994,123 for *Corporal* handling and launching equipment.

General Electric Co., $1,118,084 for digital computer facility operation . . . **Ruffe, Inc.,** Miami, Fla., $1,207,500 for bomb rack and rocket launcher . . . **Radio Corp. of America, Defense Electronic Products,** $95,637 for facilities for Government account for use in *Talos* evaluation unit, White Sands Proving Ground . . . **Birdsboro Armorcast, Inc.,** Birdsboro, Pa., $127,388 for maintenance, protection and preservation of Government-owned facilities . . . **P. J. Walker Co.,** Los Angeles, $208,000 for site prep-

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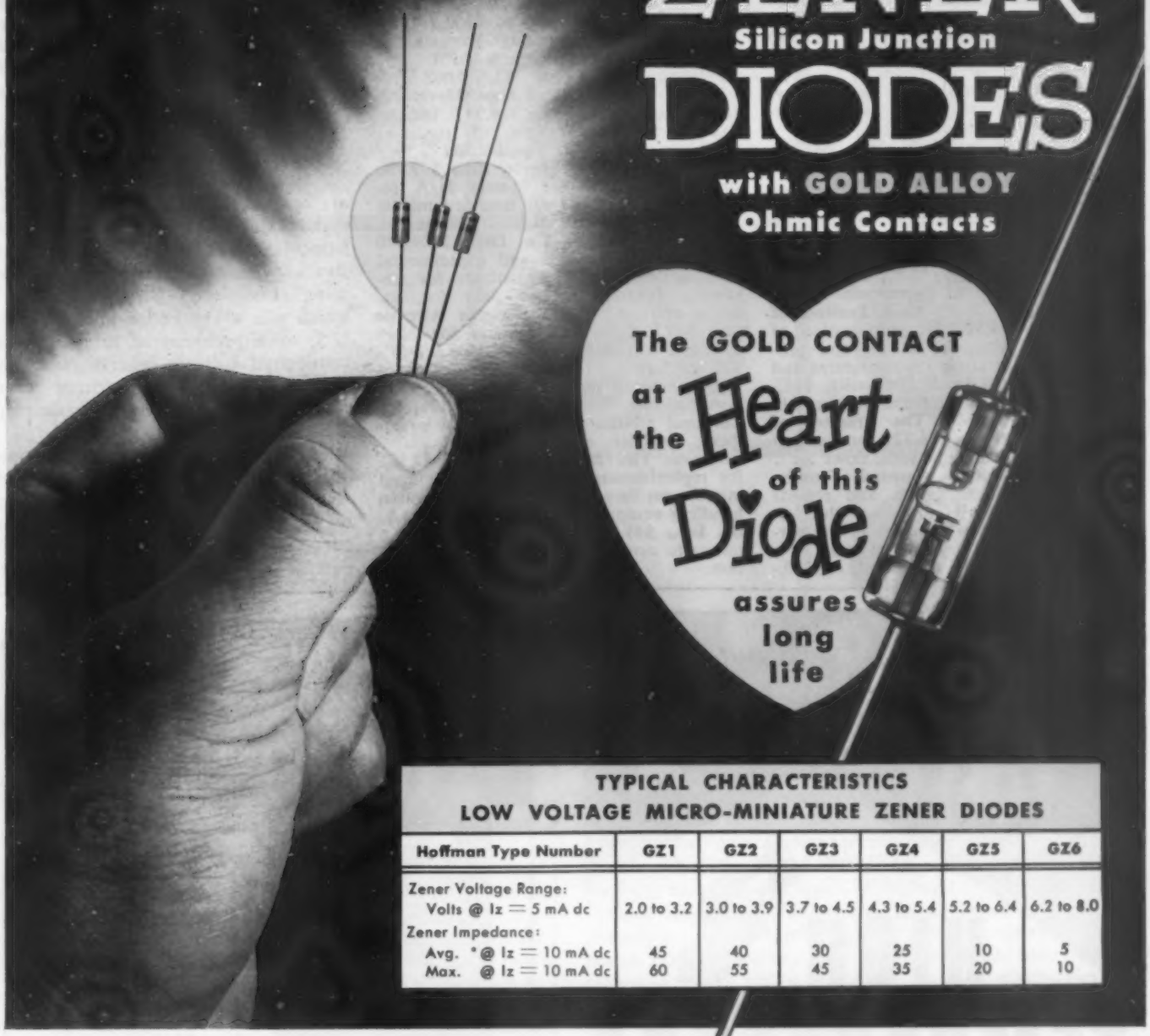

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Contract Awards

aration and access roads for instrumentation radar facilities, Tranquillon Mountain, Camp Cooke, Naval Air Missile Test Center, Point Mugu, Calif. . . . **West & Wiggs Engineering & Construction Co.,** Long Beach, Calif., $154,050 for *Nike* improvement program . . . **Linde Co., Div. of Union Carbide Corp.,** $81,600 for liquid nitrogen and liquid oxygen . . . **Rome Cable Corp.,** Rome, N.Y., $29,190 for cable, vinyl plastic O/A jacket conductors.

Massachusetts Institute of Technology, $50,000 for research and reports concerning "Aerothermoelasticity" . . . **Cornell Aeronautical Lab., Inc.,** Buffalo, $49,880 for research on spectroscopic studies of high temperature gasses . . . **The Trustees of Princeton University,** $70,000 for continuation of research on combustion processes in liquid-propellant rocket engines . . . **Rensselear Polytechnic Institute,** Troy, N.Y., $35,000 for research on study of hypersonic viscous flow phenomena . . . **Calif. Institute of Technology,** $36,590 for continuation of research for properties of air and propellant reactions at high temperatures and pressures . . . **Cornell University,** $61,857 for research on practical problems in aerodynamics . . . **The Trustees of Princeton University,** $86,725 for research on viscous effects in supersonic flows . . . **Ohio State University, Research Foundation,** $27,491 for research and reports concerning factors influencing the efficiency of small work groups in the performance of complicated team tasks.

Brush Beryllium Co., Cleveland, a $330,000 development contract from Air Materiel Command to perfect a method of rolling sheet beryllium from pressed powder slabs . . . **California Institute of Technology,** Pasadena, $635,000, engineering research and development . . . **Sylvania Electric Products, Inc., Microwave Tube Laboratory,** Mountain View, Calif., $328,000 for electron tubes . . . **Southern Oxygen Co.,** $36,208 and **Big Three Welding Equipment Co.,** $60,651, for various amounts of liquid oxygen . . . **G. W. Galloway Co.,** $150,771 for construction of helium high-pressure distribution system at Edwards AFB.

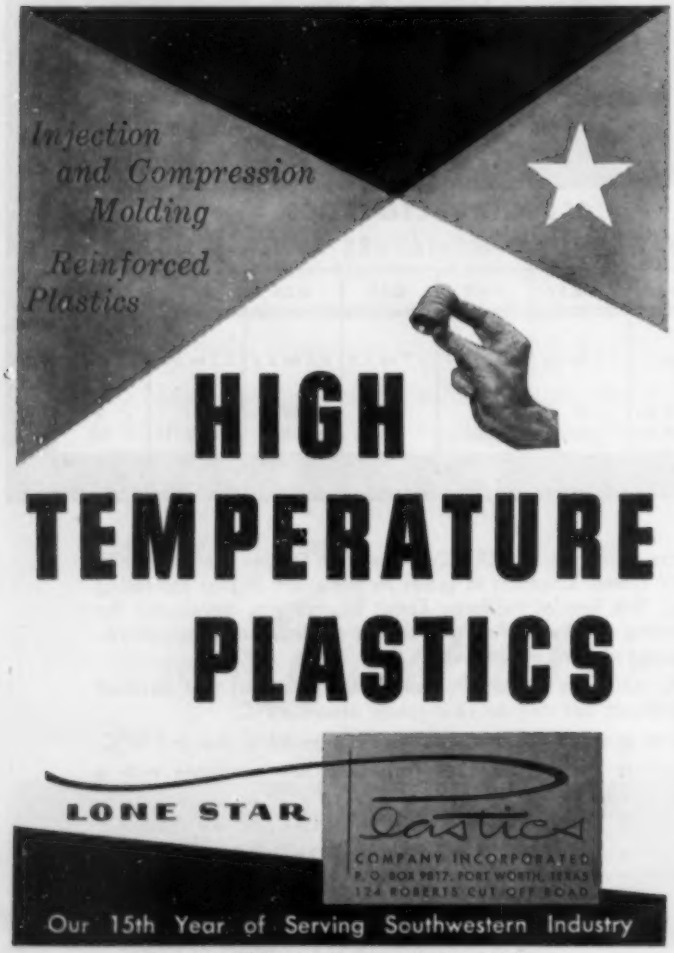
Raytheon Mfg. Co., $1,690,008 for launchers . . . **United Shoe Machinery Corp.,** Beverly, Mass., $38,715 for research and development of recoilless weapons system and ammunition . . . **Sylvania Electric Products, Inc.,** $99,990 for terminal guidance system N/A research and $375,000 for modified missile systems, N/A research . . . **Textron, Inc., Dalmo Victor Co. Div.,** $109,840 to perform theoretical and experimental investigation to devise methods for obtaining dynamic pattern data for antenna systems . . . **Douglas Aircraft Co.,** $67,711 for repair parts for *Nike* system . . . **Gilfillan Bros., Inc.,** $957,578 for furnishing and delivering of depot replenishment repair parts for the *Corporal* missile system and $420,131 for *Corporal* ground guidance control equipment, amplifier, electronic control . . . **Firestone Tire & Rubber Co.,** $147,591 for replenishment repair parts for guided missile, artillery M2 and related ground handling equipment . . . **Arthur D. Little, Inc.,** $41,885 for development of a means to neutralize intense thermal radiation.

Lockheed Expects 20% Increase in Sales

Missile sales represented eight per cent of Lockheed's total sales of more than $900 million in 1957. This proportion is expected to climb to 20 per cent in 1958 as work is accelerated on various programs, including the Navy's fleet ballistic missile, *Polaris*. This report of Lockheed's expansion in missile activities was voiced by board chairman Robert E. Gross in announcing an all-time record in company sales.

"Lockheed is making steady progress on the solid-propellant *Polaris*, to be launched from submarines or ships at sea and capable of 1500-mile flights," the aircraft executive said. "No launching dates are releasable. Extensive experience and data gained from using Lockheed's hypersonic X-17, which was a key factor in helping the U.S. solve problems of bringing intercontinental ballistic missiles back into the earth's atmosphere from outer space, is materially speeding development of the *Polaris*."

Gross said Lockheed has developed an outstanding missile in its Q-5, fastest vehicle yet devised for testing accuracy of missiles as they approach their airborne targets. The ramjet-powered Q-5, part of a complete testing system, will



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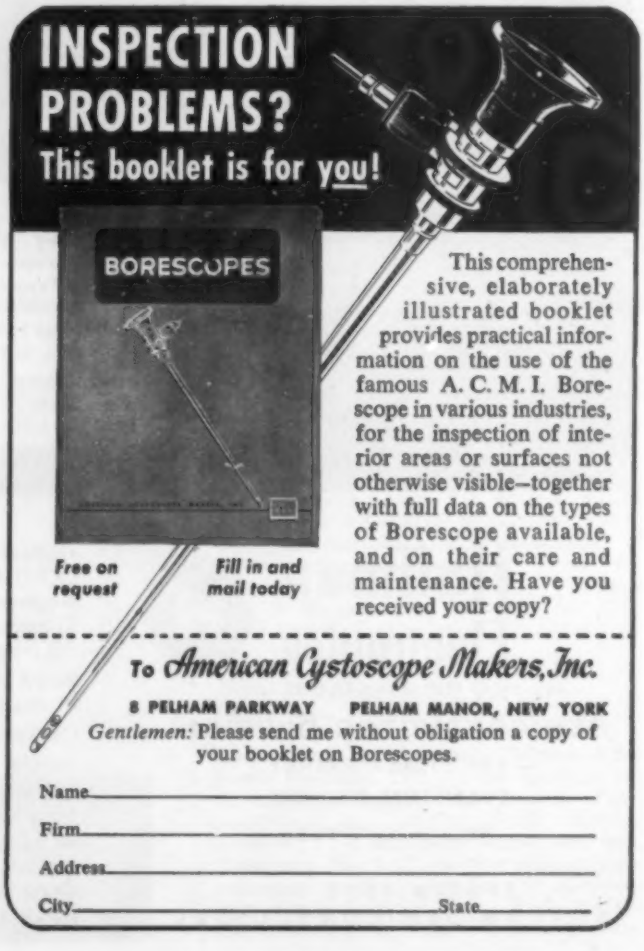
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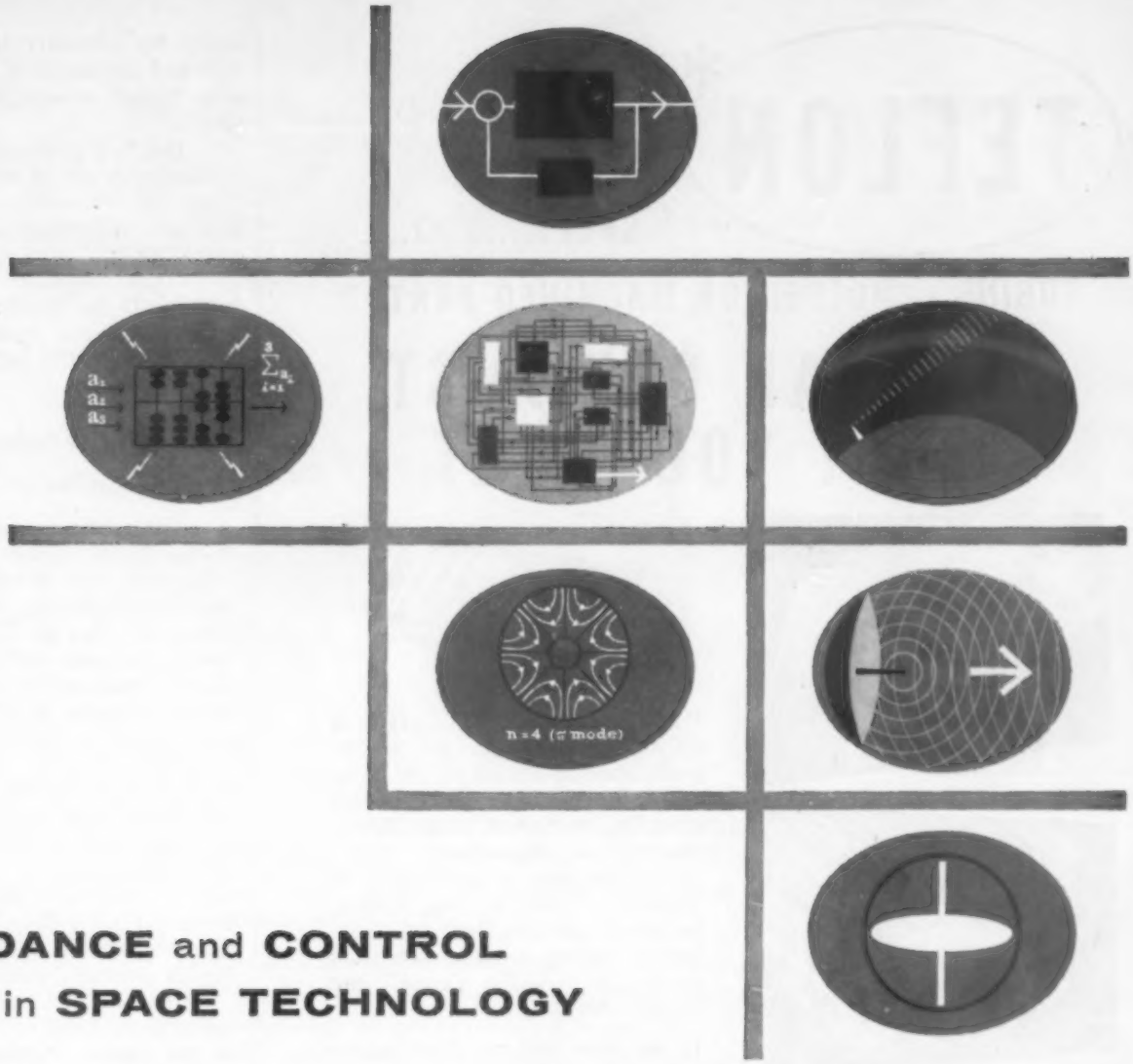

GUIDANCE and CONTROL in SPACE TECHNOLOGY

It is becoming increasingly apparent that many of the techniques and analyses, and much of the equipment, developed for the present Air Force ICBM-IRBM programs will have a wide future application in space technology. For instance, many of the guidance and control techniques for ICBM's are applicable to the space vehicles of the near future.

An important element of these applications is precision. The precision required of the guidance and control system for vehicles aimed at the moon or one of the planets is not substantially greater than that required for the Air Force ICBM-IRBM programs. And, the precision needed to guide a vehicle into a near-circular orbit of Earth is even less than that required for ICBM's.

The problem of communication with lunar and planetary vehicles is, of course, made more difficult by the much greater distances involved. This, however, is not an insurmountable difficulty if today's trends continue in the use of higher transmitted power, narrower communication bandwidths and amplifiers with very low noise-figures.

The problems of operating electronic equipment in the space beyond our atmosphere are already encountered on present ballistic missile trajectories. The principal difference in the case of space vehicle applications is the requirement for longer equipment lifetimes. Electronic equipment and power supplies will have to last for several hours or days or weeks, instead of a few minutes, under conditions of vacuum pressure, zero "g" fields, and bombardment by micrometeorites, high-energy particles, and radiation.

The preceding examples serve to illustrate some of the ways in which the ICBM-IRBM programs are advancing the basic techniques of space technology.

Since 1954, Space Technology Laboratories has been providing over-all systems engineering for these programs. Both in support of this responsibility and in anticipation of future system requirements, the Laboratories are presently engaged in a wide variety of advanced analytical and experimental work directed toward the exploration of new approaches in space vehicle electronics, propulsion, and structures.

The scope of STL's work requires a staff of unusual technical breadth and competence. Engineers and scientists who are interested in advanced experimental development projects (as distinct from development for manufacturing, in which STL is not engaged) are invited to investigate the many opportunities on the Laboratories' Technical Staff.

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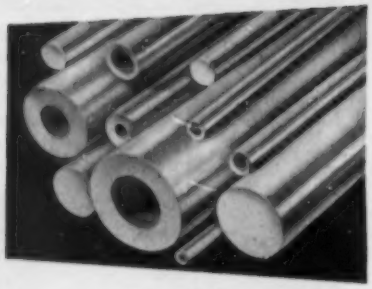

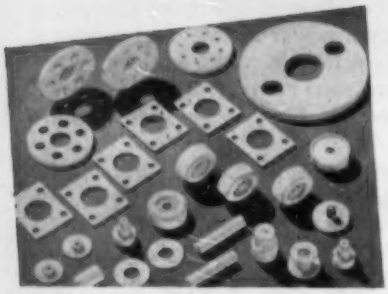

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report by telemetry the speed, direction and proximity of air defense missiles hurled toward it at supersonic speeds.

The Q-5 incorporates a firing error indicator device that has the capability of measuring accurately the course of any object coming at it from any angle.

Gross reported a $100-million back-log in the missile field. Company estimates overall sales this year will total about $750 million, a decline from 1957.

Kefauver Feels *Jupiter* Has Edge over *Thor*

The guidance and re-entry system of the IRBM *Jupiter* holds a definite edge over the IRBM *Thor*, in the personal opinion of Sen. Estes Kefauver, ranking Democrat of the Senate Preparedness Subcommittee. The senator expressed his views on the U.S. IRBM program as returning congressmen met for a special defense briefing.

Kefauver told his colleagues that he thought "both the *Thor* and *Jupiter* will work, but my present personal opinion is that for this type missile, the Army guidance and re-entry system is superior and more desirable than those contained in the *Thor*." He also doubted the wisdom of plans to hand the *Jupiter* over to the Air Force.

He said, "A serious question is raised as to whether the use and firing of the *Jupiter* should be taken away from the technicians and scientists who have developed it and have fired it successfully and place it with another service which undoubtedly has a prejudice for its own development, the *Thor*."

Air Force Releases Report on Free Radicals

The study of free radicals as possible rocket and missile propellants has been included in various fuel research reports released recently by the Air Force. The harnessing of free radicals for rocket and missile propulsion could bring substantial improvements in engine performance and fuel consumption, the Air Force researchers found, but the practical problems are "extremely formidable."

The report deals with atomic hydrogen, atomic nitrogen and the imine radical, but discourages any expectation of an early technological breakthrough or any consideration of developmental or engineering work. The report says that the free radicals might bring improvements in engine performance, including an increase in fuel economy of 100 to 700 per cent

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over conventional fuels.

The prospect for producing, storing and using bulk quantities of the highly reactive molecular fragments is said to appear discouraging. The report recommends active basic research to explore the formidable problems and expand knowledge of the substances, but warns that the program should be a speculative one with little probability of practical development.

The 29-page report, designated PB 131076, has been made available by the Air Force through the Department of Commerce, Office of Technical Services, for 75 cents.

Construction Begins on Four *Bomarc* Sites

The Air Force has released $46 million to begin construction of *Bomarc* missile facilities at Dow Air Force Base, Maine ($10.2 million); McGuire Air Force Base, N.J. ($12.5 million); Otis Air Force Base, Mass. ($10.2 million) and Suffolk County Air Force Base, Long Island, N.Y. ($12.5 million).

These missile sites will include launching and storage facilities, missile operating and maintenance facilities, control and protection facilities and supporting utilities.

Meanwhile, a contract to install ground support equipment in the first *Bomarc* base at Eglin AFB, Fla., has been awarded by Boeing Airplane Co. of Seattle, Wash., prime contractor for the *Bomarc* weapon system.

Designated as an employment and suitability test base, the facility is currently under construction by the Army Corps of Engineers. After the site has been prepared, Paul Hardeman, Inc., will begin installation of launchers, ground testing equipment and maintenance equipment.

The *Bomarc* base will be used to check out its operating functions, which, if proven, will be incorporated in the four new bases.

The Boeing contract with Hardeman calls for supply of supporting services in addition to the installation of equipment, and for assistance to Boeing in calibrating and checking out the system. The supporting services called for in the contract include guards, transportation facilities, maintenance and warehousing services.

Boeing will manage the test base until it is turned over to the Air Force. About 60 Boeing and 300 Hardeman people will be employed in the installation, checkout and calibration phases of base preparation.

Titan Offered as Manned Carrier

The present *Titan* configuration could place a manned satellite in orbit and return it safely to earth when desired. This disclosure was made by H. W. Merrill, vice president of The Martin Co. at a Chamber of Commerce meeting in Denver, Colo.

Merrill, in discussing the tasks that could be assumed by the *Titan* in a space exploration program, said: "Substituting a satellite for the nose cone warhead would enable *Titan*, in its present configuration, to launch an earth satellite weighing more than a ton. Reconnaissance flights around the moon could be accomplished by adding stages. *Titan* has a considerable design growth factor applicable to the hardware requirements for probing space and reaching the moon.

"The same engines now in production that will boost *Titan* to 25,000 feet/second velocity" he added, "can boost a somewhat lighter body to the escape velocity of 35,000 feet/second or to an orbital path around the earth. Using the same number of stages, the ratio of thrust to weigh would be greater by using a lighter payload, and higher accelerations and velocities could be reached before burnout. It would also be relatively easy to add

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still another stage. The same guidance system that will enable the *Titan* warhead to reach its target within a permissible accuracy would also be sufficiently accurate to hit a target much smaller than the size of the moon, even at that increased range."

He announced that Martin proposed a moon project to the government before *Sputnik* I was launched. The proposal, currently under consideration by the Department of Defense, suggests how the United States can reach the moon before Russia. Merrill pointed out that Martin is not the only contractor that has suggested utilization of the *Titan* in proposals asking for more active participation in the U.S. space program.

The Martin Co. vice president, when questioned whether history would record the Russian satellites achievement as the greatest of this age, said: "History will decide whether *Sputnik* I will share an equal honor with the Wright brothers flight, or whether the first manned space flight will hold most significance."

Reaction Reports 50% Sales Increase

Reaction Motors, Inc., reports that sales for 1957 totaled about $24 million, an increase of 50 per cent over 1956. Adjustments during this period resulted in a backlog reduction of about $17 million, with no contract cancellations reported.

The company's preliminary analysis also reveals an increase of 32 per cent in total facilities, 11 per cent in working capital and about 23 per cent in personnel.

Research and development work continued to the RMI's main activity in 1957, although substantial progress was made toward greatly expanded production operations.

Based on development contracts currently held and under negotiation, the company anticipates that 1958 will be another growth year.

Vanguard Program Known to Only 20%

Researchers at the Survey Research Center of the University of Michigan have revealed that a survey made in April 1957, showed that 54 per cent of the people in this country never heard of the *Vanguard* program, satellites, plans to launch satellites, or any other phase of this IGY program. Only 20 per cent of the persons interviewed had any real idea of what the program was expected to accomplish although many had heard it in a general way.

Russian Claims U.S. Neglects Talent

Too much American dependence on foreign brainpower may be an important factor in U.S. rocket failures, according to a leading Russian space scientist.

Prof. Y. Pobedonostsev, writing in the Soviet magazine NOVOYE VREMYA (NEW TIMES), claims that the United States has tried to import missile experts in the same way it has attracted movie stars and pugilists. The result, he says, is that America has neglected the training of its own people. The article states in part:

"The immediate technical cause of America's unsuccessful launching of an earth satellite may have been a disturbance in the functioning of the smallest instrument or device, or the fault may have lain with the actual design of the rocket or its propulsion unit. Naturally no research team is guaranteed against accidents. But the systematic American rocket failures impel one to look deeper for the reasons.

"To my mind," Pobedonostsev went on, "the root of the trouble lies in the U.S. approach to building up scientific and engineering forces, which America has attempted to do by importing rather than training its own.

"This is not a new thing. It has been going on for decades. From Russia, for example, S. P. Timoshenko, the father of modern structural mechanics, went to America. Also the aircraft designers A. P. Seversky and I. I. Sikorsky and a number of other important experts.

"From Germany, the United States was able to bring over Dr. Albert Einstein, author of the theory of relativity; and the same happened with leading Austrian, Swiss and Chinese authorities on aerodynamics. Following Germany's defeat, her foremost rocket experts—von Braun, Dornberger, Ehricke, Oberth and many more were taken over to America.

"There is also the fact, noted in American technical literature, that in 1940 the British government, unable to undertake large-scale rocket research and production at home, was obliged to turn over to the United States technical documentation on jet aircraft engines and missiles.

"And so, rocket development in the United States has proceeded largely through the importation of foreign brains and on the basis of foreign research. But this has proved a very mixed blessing because the training of native forces has failed to receive proper attention.

"National American science is in danger of becoming a rather tenuous concept." Pobedonostsev added that Russian rocket science and technology have been developed through training of its own people and through complete and unselfish cooperation in all stages of planning.

"But in the United States, the different parts of some complex unit—a ballistic missile, a long-range aircraft, or an earth satellite—are manufactured by different firms, whose narrow interests paralyze the researchers' natural and patriotic desire to work together. Each firm is out to get more of the orders, to make more money out of the common undertaking. Who, then, is going to pool experience with his competitor and help him?

"Nor is it only the firms that compete. There is perpetual wrangling even between the different services. The Army squabbles with the Air Force over who shall make IRBM policy, and the Navy is at loggerheads with the Air Force over guided aircraft missiles.

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economic planning, everything tends toward concerted and mutually-helpful endeavor by the different research and production centers. These centers have everything they need—personnel, materials and money. They work according to a coordinated plan in the interests of the state as a whole."

GE Promotes Turbojets For Ballistic Boosters

The Aircraft Gas Turbine Division of General Electric is suggesting the use of turbojet engines as a first-stage platform for launching ballistic missiles and space vehicles. John B. Montgomery, general manager of the division, said the turbojets would lift the missile or space vehicle above the dense layers of the atmosphere where the rocket engine would take over for the remainder of the flight. Tremendous savings in total takeoff weight plus the ability to recover the booster for reuse were cited as the major advantages of the system.

"Air-breathing boost units, which could have vertical takeoff and landing capabilities, simply would be launched or landed at appropriate locations as occasion demanded. Transportation and ground-handling facilities to support such a launching site would be very much simpler than the elaborate structures being built for today's ballistics missiles," Mr. Montgomery declared.

He said that advances in turbojet technology now being achieved could make possible the development of an air-breathing boost for launching ballistic missiles and space vehicles within the next few years.

AMRI Says Missiles Not 'Subhead' of Airframes

The Associated Missile and Rocket Industries has stressed the importance of an overall awareness of the evolution of a missile industry in the United States.

In a recent report, AMRI pointed out that the missile industry is comprised of airframe, electronic, chemical and automotive giants working side by side with hundreds of subcontractors. It added that, although the airplane manufacturers have played a major role in the evolution of this industry, missiles should no more be a subhead under airframe than aircraft under automobiles.

AMRI emphasized the need for a concentrated national effort, free from dominance by "older" weapons and ideas, in order for the United States to gain space supremacy. "This is recognized in the strong demand for centralization of authority—in Congress, in official agencies, in the armed forces, and in scientific development—for missiles as a field in itself, subordinate to no other."

A survey of prime and leading subcontractors of the missile industry recently compiled by AMRI lists 960 companies distributed within eight sections of the U.S. The Mideast heads the list with 342, followed by Great Lakes, 219; Far West, 212; New England, 104; Southeast, 31; Plains, 31; Southwest, 17; and Rocky Mountains, 4. In states, California leads with 208, followed by New York with 167.

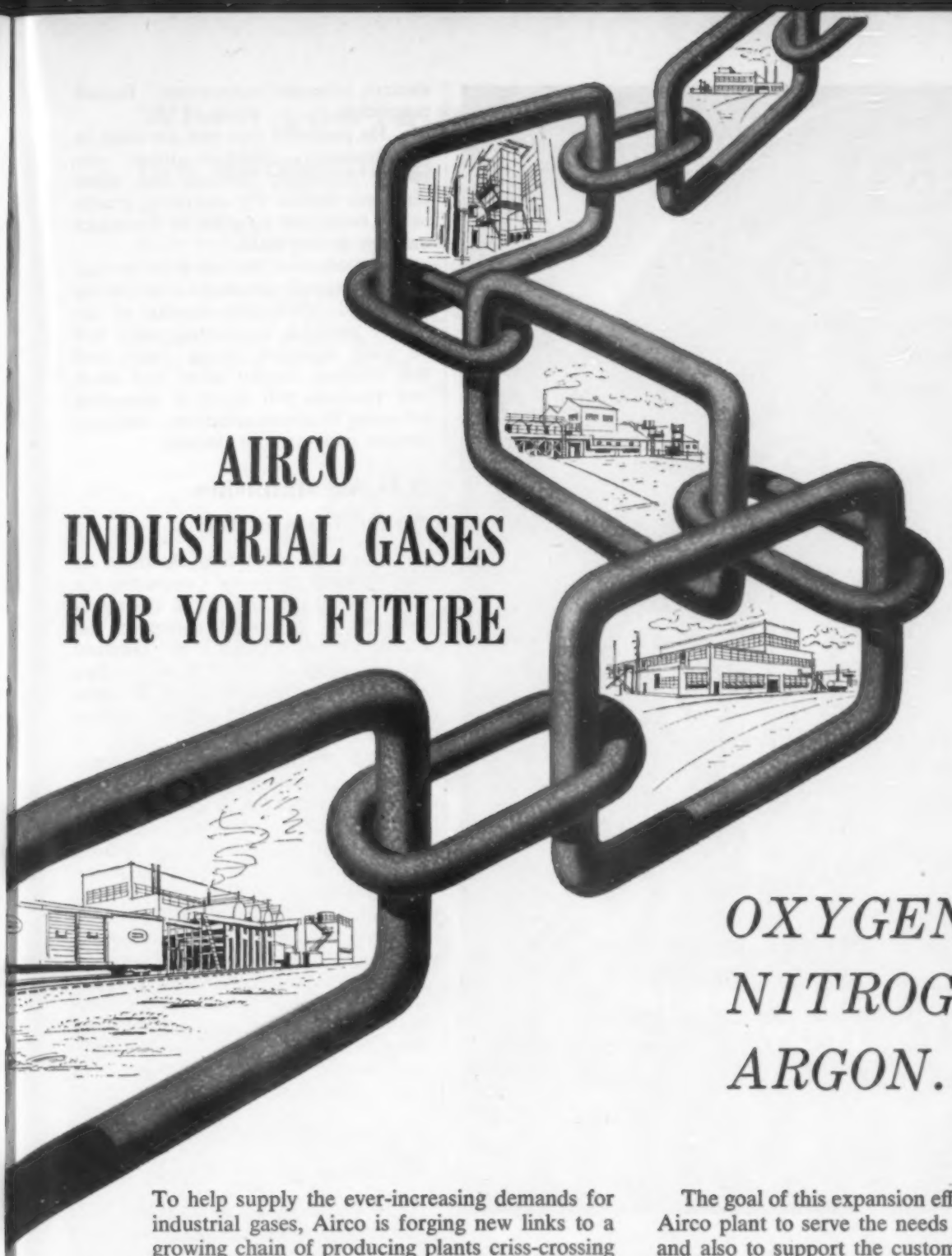
Air Reduction Dedicates New LOX Plant

Hughes Products, the commercial division of Hughes Aircraft Co., has increased its sales during the past five years from $400,000 to an estimated $40 million in 1958, Rollin M. Russell, an executive of the company, reported recently.

"The commercial electronics industry has not been subject to either rapid inflation or deflation during the year and, as a result, will be able to continue its marketing of a wide variety of new products while conducting an intensive program of applied research," Russell said.

The anticipated gross of $40 million during 1958 will contrast with sales of $22,500 million for 1957. He said $5 million would be spent on applied research, none of it involving military contracts.

"The bulk of our sales dollars—in excess of 30 million—will come from diodes, transistors, rectifiers and other semiconductor devices, but we anticipate a healthy increase also in sales of



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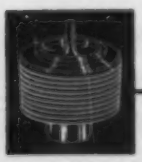

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electron tubes and instruments," Russell continued.

He predicted that new advances in semiconductors, electron tubes, circuitry, automatic controls and other electronic devices will contribute greatly to the continued progress of American industry during 1958.

Russell said the big push toward automation will get under way during 1959 and 1960; that results of intensive research in electron tubes will be most apparent during 1958; and that brighter display tubes and other new products will result in important advances in communications, detection devices and read-out devices.

NACA Establishes Space Committee

James H. Doolittle, chairman of the National Advisory Committee for Aeronautics, has announced the establishment of a special committee on space technology. Dr. H. Guyford Stever, associate dean of engineering at Massachusetts Institute of Technology, has been selected to head the new committee.

The NACA authorized establishment of the committee and Dr. Stever's appointment as head of the new group. The committee will assist the main committee in coordinating and defining increasing efforts of the NACA on problems of space flight.

The space technology committee will have a total of about 15 members. Each one will be a leader in some aspect of the broad field. An early organization meeting of the group is planned. In addition to the special committee, there will be a number of subcommittees dealing with specific aspects of space technology.

Firecrackers Explore Weather at 60 Miles

High-explosive "firecrackers" built into rocket nose cones have been used to explore the weather to an altitude of 60 miles in a series of tests for the International Geophysical Year at Fort Churchill, Canada.

Physicists of the U.S. Army Signal Engineering Laboratories at Fort Monmouth, N.J., made the studies in a series of five summer rocket firings using *Aerobee* rockets.

The special *Aerobees* were loaded with 19 high-explosive grenades, which ejected from the nose cone at pretimed altitudes to sound out temperatures and winds simultaneously for the first time at such altitudes. The blasts were heard by delicate sound-ranging devices on the ground.

The time it took for the sound of each blast explosion to reach the

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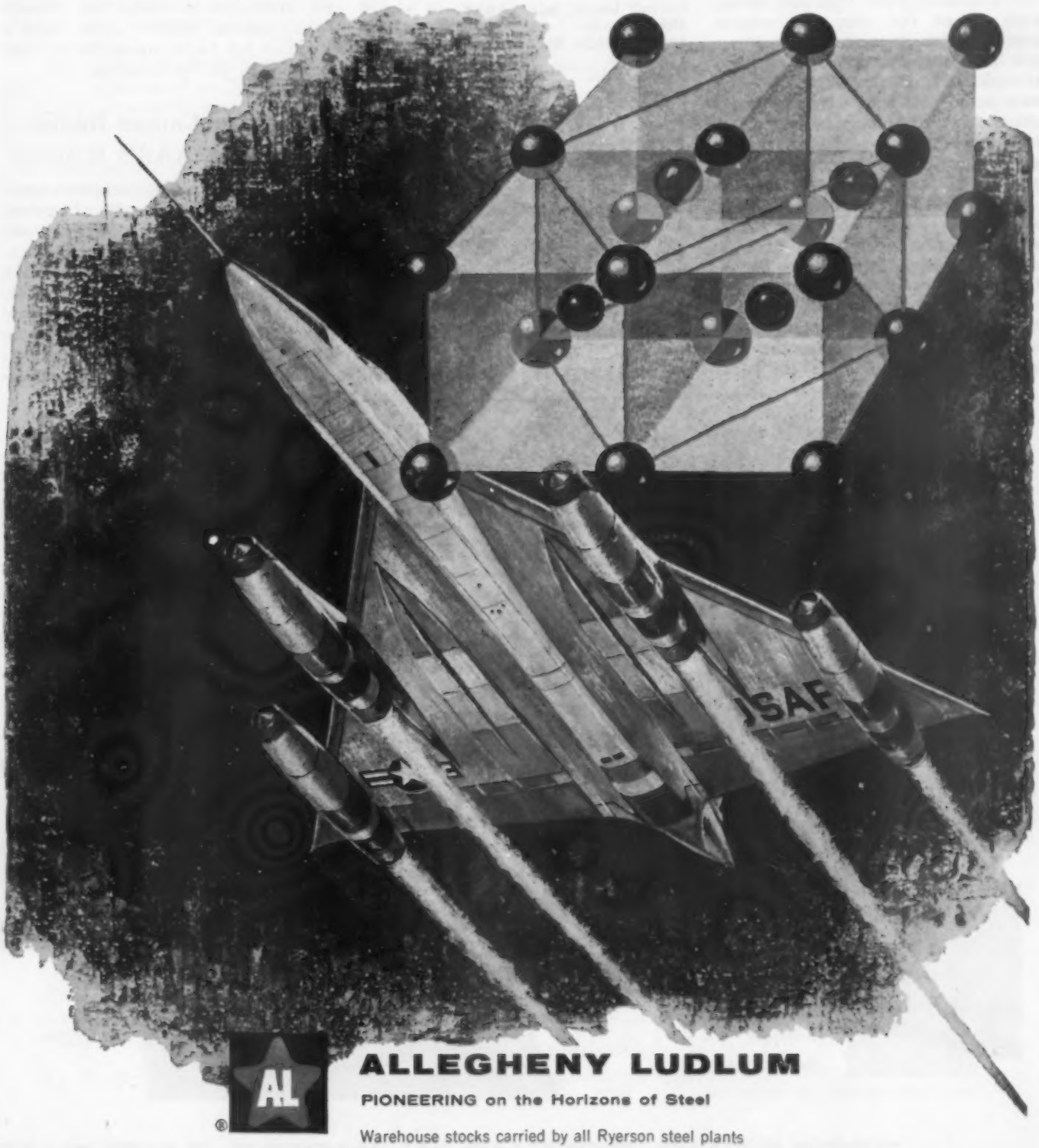

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ground gave scientists an accurate indication of winds and temperatures. After readings are analyzed, the data will be made available to scientists of the more than 40 nations participating in the IGY.

Preliminary examination of the data from the firings indicates that winds of 300 miles an hour or faster are not uncommon in the stratosphere, where temperatures plunge to −100°F. It also appears that high-altitude winds over Canada are much stronger than over the United States.

The five Fort Churchill firings were spread out over the summer months to get representative samplings, and launchings were made in morning, afternoon, evening and night. All firings were successful. They were the second phase of a three-pronged study of the high-altitude air movements which have a profound effect on weather on the ground.

Tests have already been completed over White Sands, N.M., and next year the same Army team plans to make soundings from Guam in the Pacific. Another series of four rockets will be launched this winter from Fort Churchill to get representative high-altitude wind figures for the cold months.

Allegany Discloses *Deacon* Rocket Details

CUMBERLAND, Md.—Hercules Powder Co., operators of the Allegany Ballistics Laboratory, have furnished details of two *Deacon* rocket models, the JATO X204 (solventless extruded grain) and the JATO X220 (double-base cast grain). Both grains use an internal burning star configuration.

	X204	X220
Overall length, in.	105.7	110
Diameter, in.	6.25	6.25
Loaded weight, lbs.	150	152.5
Propellant length, in.	96.5	——
Propellant weight, lbs.	100	108 (w./inhib.)
Inhibitor thickness, in. (cellulose acetate)	0.1	0.125
Burning time, sec.	3.28	3.19
Total impulse, lb.-sec.	20,000	18,300
Motor case thickness, in. (aluminum)	0.12	0.12
Igniter	100 g FFFG black powder	40 g black powder 20 g trench mortar sheet

Development of *Deacon* began in January 1945. The rocket has seen extensive use since then. In 1956 some 264 extruded propellant *Deacon*s and over 1300 cast grain *Deacon*s were shipped to over 20 propellant groups.

NACA has fired the *Deacon* to a speed of 6900 fps., and altitudes up to 70 miles. Sandia Corp. has used the rockets to power a large centrifuge where lateral accelerations of 200 g were experienced. Other *Deacon* rockets were used for *Pogo, Rockoon, Terrapin,* and *Father John.* The latter configuration tested the *Honest John* system. *Father John* used a standard M6 JATO around which were wrapped 6 to 10 *Deacon*s.

Ion Layer Causes Radio Blackouts, AAAS Reports

Scientific probings into the upper atmosphere with the aid of rockets have corroborated the belief that radio "blackouts" are caused by an extra layer of ionized particles which occurs during solar flares 10 to 12 miles below the lowest portions of the ionosphere, the American Association for the Advancement of Science reports. Other rocket experiments have estab-

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lished that this layer is caused by the sun's X-ray emissions.

In a summary of the first six months of the United States IGY program, the AAAS reports that considerable data involving measurement of pressure, temperature and density of the upper atmosphere was gathered with aid of the rocket vehicle program.

During the first six months, 81 rockets were fired, including 9 *Aerobees*', 5 *Nike-Cajuns*, 13 *Nike-Deacons*, and 54 *Rockoons*. The report states that the *Sputniks*, in addition to the rockets, have proved very useful in gaining new information concerning the ionosphere.

The AAAS findings reveal the probable existence of an "electro-jet," a narrow equatorial electric current which circles the earth in the high atmosphere. This is one of three hypothecated currents of perhaps several hundred thousand amperes circling the earth. The others girdle the North and South magnetic poles.

Hugh Odishaw, executive director of the US-IGY Committee and author of the report, noted that IGY data is already beginning to flow into three World Data Centers, in the United States, the USSR, and in Western Europe-Japan.

Italian Missile Program Underway

The existence of an Italian missile program has been officially confirmed by the Ministry of Defense and although its specific structure is not known, it is possible to outline the general characteristics of the program.

The first operative units to be armed with missiles will use *Nike-Ajax*, and at least three battalions will be supplied with the weapon before 1959. Placement is not expected to be around any one major city, but more likely will be planned to provide three cities with partial protection. They are Rome, the capital; Naples, NATO headquarters; and Milan, the major economic center of the country.

In addition to receiving *Nike-Ajax* from this country, Italy has expressed considerable interest in building weapons under license from foreign companies. The first of these licenses has been granted by Oerlikon for its surface-to-air missile, the *Oerlikon* 54, to its associate firm, Contraves Italiana. The *Oerlikon* 54 is a beam-rider using a liquid-fueled engine (nitric acid/kerosene). The missile has no external boosters and its guidance system is efficient to an altitude of 50,000 feet. In mid-December, a type 54 rocket under evaluation test is understood to have exploded at 2300 feet over the Sardinian test range.

Other missiles that interest the Italian government are the *Nike-Hercules*, Bristol *Bloodhound* and the *Terrier*, which will probably enter service with the Italian Navy. Britain is understood to be willing to sell Fairey *Fireflash* and de Havilland *Firestreak*, while the United States may be willing to supply both the radar- and infrared-guided *Falcon*, as well as the Philco *Sidewinder*.

A modest experimental program is underway for the development of original Italian weapons. One of these is the A.R.14, a beam-riding liquid-propelled missile. The A.R.14 is 23-feet long, weighs about 1100 lbs. and has a 2200-lbs.-thrust engine using nitric acid and kerosene which burns for 29 seconds. Range is over 65,000 feet altitude, and powered flight is understood to carry the missile above 33,000 feet.

Simultaneously, a program is underway to develop an infrared-guided missile. Coordinated by Centro Razzi, the program has come up with a missile designated the C.7, a small, solid-fueled missile fitted with a rectangular

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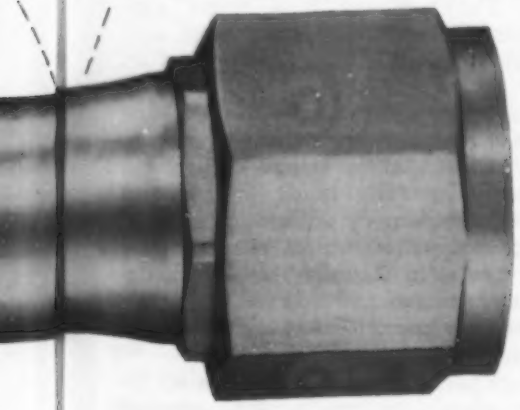

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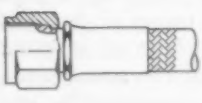

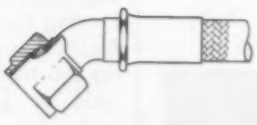

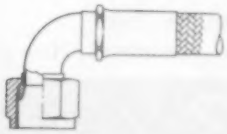

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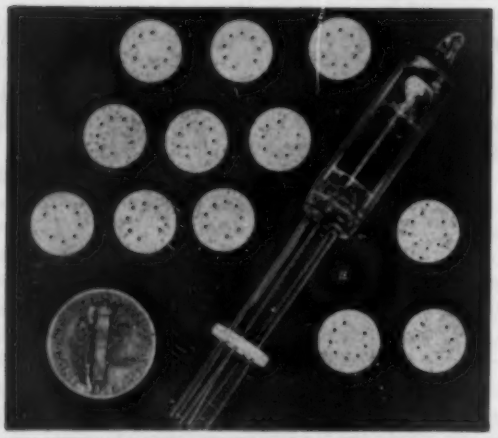

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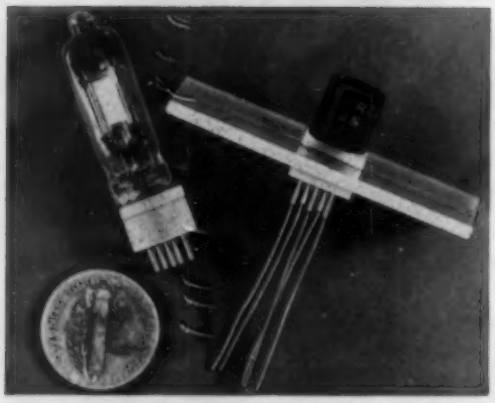

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wing, with terminal plates and several intermediate bulkheads. In transonic conditions, the C.7 coasts for the greater part of its flight, maneuvering by altering the wings' angle of attack. The C.7 has not been tested against targets or drones and therefore no indication of its efficiency is available.

Another Italian effort in the missile field is the *Icaro*, a ballistic missile understood to use ramjet power. Prototypes were scheduled for completion by December 1957. It has been reported as filling the same role as our *Honest John*, with which the Italian Army will be supplied.

Navy to Ask Additional *Polaris*-launching Subs

The Navy has decided to ask Congress for a total of nine *Polaris*-launching submarines powered by nuclear engines, it was revealed at a recent Congressional committee hearing. The missile, currently expected to become operational by 1960, has made "amazing" progress, according to Navy spokesmen, and even better progress could be realized if the necessary funds were available.

Adm. Arleigh A. Burke, Chief of Naval Operations, told the committee that *Polaris* will have limitations even in a general war because the system is "only good for mass destruction." Further details on this remark were stricken from the published transcript.

Burroughs Making *Atlas* Computer

Burroughs Corp. has announced it is making the prototype for the electronic guidance computer used in the current *Atlas* ICBM test program at Cape Canaveral, Fla.

The company is a prime contractor in the *Atlas* program with contracts totaling several million dollars for design, development and production of electronic data-processing systems for the *Atlas* guidance system.

The guidance system, which has been successfully tested in a recent *Atlas* launching, is a prototype of production models which the company may build in Detroit. The design, development and assembly of prototypes have been carried out in the company's laboratories in Philadelphia.

Prior to launching a missile, information concerning the planned trajectory is fed into the computer. During the initial stages of the missile's flight, a constant flow of information on the missile's course, speed and altitude is given automatically to the computer.

The computer compares this data with the information previously pro-

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grammed, and through a transmitting system can instruct the missile to make necessary changes to keep it on the predetermined trajectory to the target.

Current flights of the *Atlas* are highly instrumented to confirm the thoroughness of ground tests of the missile's components and also to discover any weak points in construction under actual flight conditions which need improvement.

Rocket Bomber Approved for Development by AF

Bell Aircraft's proposal for a boost-glide bomber has been formally approved by the U.S. Air Force. A contract, m/r has learned, is now being negotiated. This vehicle, designed under the direction of Dr. Walter Dornberger (formerly of Peenemunde, now of Bell), is based in principle on the mid-30's concept of Dr. Eugen Saenger.

The proposal, which the Air Force is reported to have approved, entails not only the well-known boost-glide concept but is projected to the point of an orbiter. In its initial stages the vehicle would have a range of about 12,000 miles and a velocity over target of about 12,000 miles per hour. A major advantage of this concept is that it would have the flight characteristics of a highly sophisticated missile but would have a man along as well to monitor the vehicle's operation and to provide direct guidance of the rocket bomb to target.

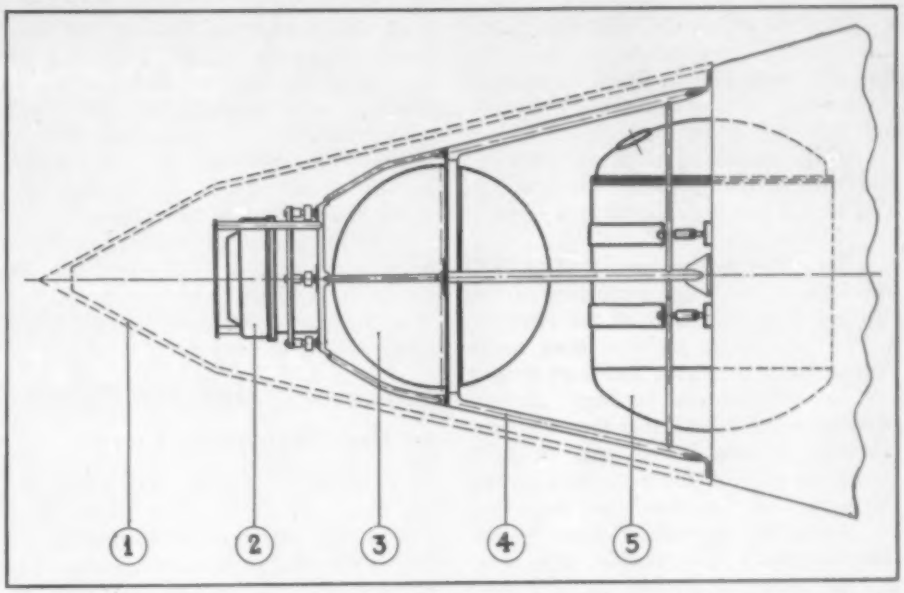
BDSA Cancels Order for Titanium Products

The Business and Defense Services Administration has canceled its order M-107 for titanium mill products. The cancellation was due to reduction of military demand for the metal to a point where the order was no longer necessary.

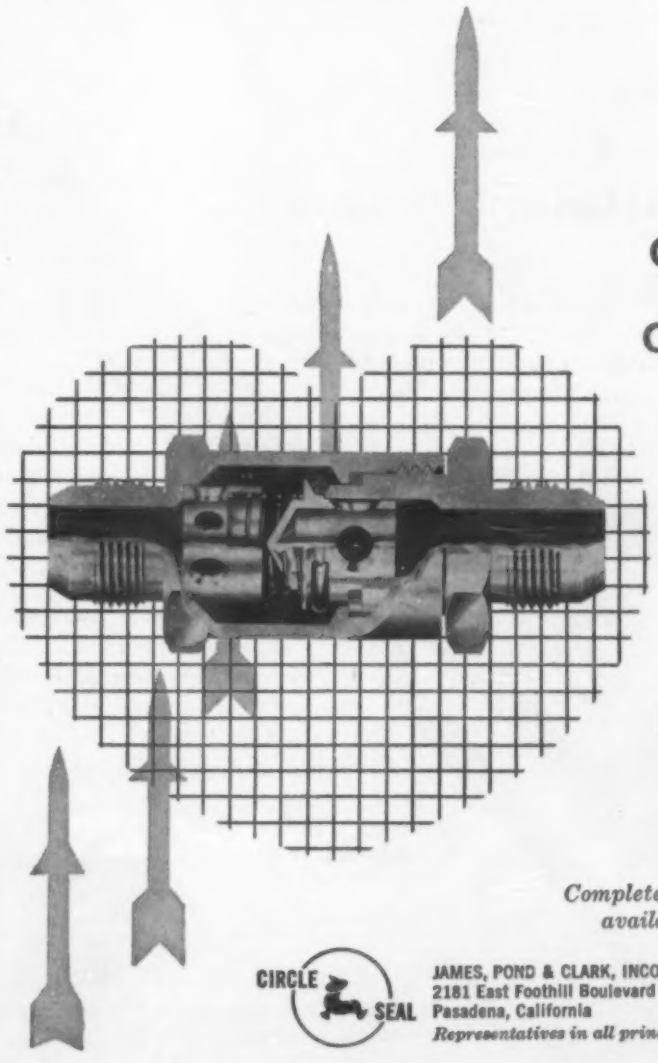
The BDSA said the revocation will result in greater savings in paperwork by elimination of the requirement that mill schedules in the industry be submited for the approval of the Defense Department. More latitude will be given industry in the expansion of civilian business as another result of the cancellation, but defense orders will continue to have a priority rating.

Order M-107 originally required producers of titanium mill products to submit monthly production schedules to the Pentagon for review. The DOD then recommended what changes were thought necessary, with BDSA taking final action. The procedure was adopted during the period when the Defense Department was taking 95 per cent of the total titanium supply.

Diagram of *Sputnik* II's Payload



A diagram of the forward section of SPUTNIK II shows the protective nose cone (1), the instruments used to record solar activity such as ultraviolet and X-rays (2), the sphere containing radio transmitters and other instruments unidentified (3), the frame enclosing the satellite's scientific equipment (4) and the cabin containing the dog, Laika (5).



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AVCO Proposes Manned Re-entry System

AVCO Research Laboratory has submitted a proposition to the Air Research and Development Command for sending man into orbit and returning him safely by parachute. It can be ready, according to Dr. Arthur R. Kantrowitz, lab director, "as soon as a reliable *Titan* is available as a launching vehicle."

Dr. Kantrowitz says that AVCO has solved the design problems of the re-entry parachute and of the environmental capsule to carry a man many times around the earth and then protect him as he returns through the atmosphere. He stated also that the very complex structural problems of both parachute and capsule have been solved. He noted also that should the passenger of the AVCO satellite become incapacitated for any reason, it is subject to complete remote control from the ground, and that the system could be brought back to a pinpoint landing even though the man inside were unconscious.

Dr. Kantrowitz thinks that parachute re-entry is much more practical than other proposals involving winged re-entry, retro rockets, etc. "These are Cadillac approaches," he says. In addition, Dr. Kantrowitz insists that contrary to popular belief, parachute re-entry can be just as accurate, as to landing point, as any other system and "a lot simpler." By parachute, he does not mean the cloth umbrella that people usually think of as a parachute, but more like a drag brake of metal.

Other manned re-entry systems have been proposed by Convair, Martin, Space Technology Laboratories (Ramo-Wooldridge subsidiary) and Cook Electric Co., to mention a few.

Summers, Mercast Merge as the Summers Corp.

Summers Gyroscope Co. and Mercast Corp., an affiliate of the Atlas Corp., have merged and will henceforth be known as the Summers Corp. The merger, approved by the boards of directors of the two companies, is now subject to the approval of the stockholders, the Civil Aeronautics Board and the California Commissioner of Corporations. Mercast has assumed responsibility for the management of Summers, under the direction of Jack S. Warshauer, vice president of Mercast and executive vice president and chief executive officer of Summers.

The merged company, which manufactures military products for missiles and aircraft, will have three divisions, each a separate entity. They will be the Summers Gyroscope Co., Mercast Corp., and Gray and Huleguard, now a subsidiary of Mercast.

Northrop Engineers Move to New Science Center

Northrop aeronautical engineers have begun occupancy of a 380,000-square-foot multimillion-dollar scientific research center at Hawthorne, Calif. Approximately 2800 engineers and scientists, working on advanced guided missile and airframe projects, will be housed in the new research center.

Prime structure is an air-conditioned six-story tower equipped with automatic elevators. The building features modular interiors designed to specifications of Northrop's human engineering group for maximum job efficiency.

Immediately adjacent to the tower is a two-story structure housing an ultramodern drafting room on its second floor. Its ground floor will contain Northrop's computer research center,

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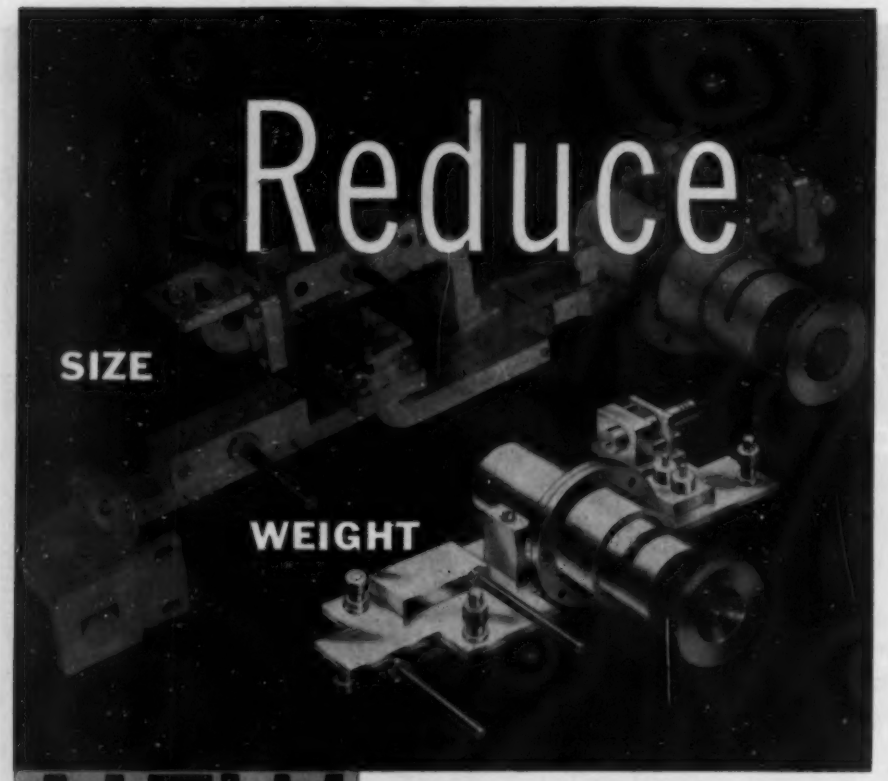

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Other new facilities constructed simultaneously with the scientific research center include a 46,000-square-foot engineering test laboratory, a high-performance wind tunnel, a new air-conditioned cafeteria, a modern "showcase" building to house product displays, a new tooling structure, tank sealing building and improved underground utilities.

Additional facilities built during the same period for the U.S. Air Force to be used by Northrop include a muffler for testing guided missile engines, an environmental laboratory for simulation of various flight and launch conditions in aircraft and missile testing programs, and a guided missile preflight installation.

Ohio State Records Death of *Sputnik* I

The radio telescope at Ohio State University, using a new system of radio reflection, recorded the final flight of Russia's first satellite. The data of *Sputnik* I's last hours was compiled by the university's tracking team under the direction of Prof. John D. Kraus.

Three individual parts of the satellite were tracked in late December. These were identified as the last-stage rocket structure, the satellite sphere, and the protective nose cone. The two largest parts began to break up around the first of the year and by January 6 eight separate pieces were distinguished. One of these either was vaporized by aerodynamic heating or completely disintegrated by the following day. Within 24 hours, three pieces more ceased to exist. By January 9 only one fragment remained in orbit. Ninety-eight days from its launching, on January 10, no trace of this final fragment could be found.

The radio telescope tracked the fragments by reflecting radio waves off the ionization streams produced by the hypersonic flight of the satellite through the rarified upper atmosphere. The radio signals were broadcast at a frequency of 20 megacycles from station WWV of the National Bureau of Standards.

The Soviet news agency TASS announced that *Sputnik* I "ceased to exist" on January 4, the first official statement to that effect. The first artificial earth satellite, launched last October 4, circled the earth for 92 days and made

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approximately 1400 revolutions, covering well over 37 million miles.

TASS noted that, in view of its obligations, the Soviet IGY committee was preparing and circulating a preliminary scientific report to other organizations in the IGY program. One definite bit of information that *Sputnik* I established, according to TASS, was that the danger from meteorites had been less than expected. The agency said the sphere had passed through several meteor showers undamaged.

Boeing Receives Contract for 100 More *Bomarcs*

Boeing Airplane Co. has received a letter contract for approximately 100 more *Bomarc* area defense missiles. This latest production contract, for an undisclosed figure, is in addition to the approximately $146 million awarded for the *Bomarc* from fiscal 1958 funds.

First production vehicle recently came off the assembly line at Seattle.

Major portions of the missile—a reported 70% of the entire system—is subcontracted, with assembly at Seattle. Production at the company's Developmental Center will continue until facilities are completed at an Army depot plant leased by Boeing.

The *Bomarc* is capable of climbing to 60,000 ft., cruising at Mach 2.5 to a range of 250 miles, locking on with its target-seeking system and intercepting with a nuclear warhead. *Bomarc* bases probably will be located along the northern border of the United States, with heaviest concentration in the northeastern section for protection of dense industrial areas.

The missiles can be fired in salvo and directed to intercept individual manned bombers or air-breathing missiles.

Orval Cook Suggests NACA as Space Agency

WASHINGTON, D.C.—Gen. Orval R. Cook, president of Aircraft Industries Assn., has suggested that if a government agency is needed to take responsibility for accelerating U.S. efforts in space travel, the National Advisory Committee for Aeronautics, or a similar existing organization, could provide this direction.

He believes decisions, not new agencies, are needed now. He told the Institute of the Aeronautical Sciences that staffing of any new agency would make serious inroads in the scarce and highly specialized scientific and engineering talents involved in the space flight program. The major bottlenecks in our efforts to penetrate the frontiers of space, he said, have been our ele-

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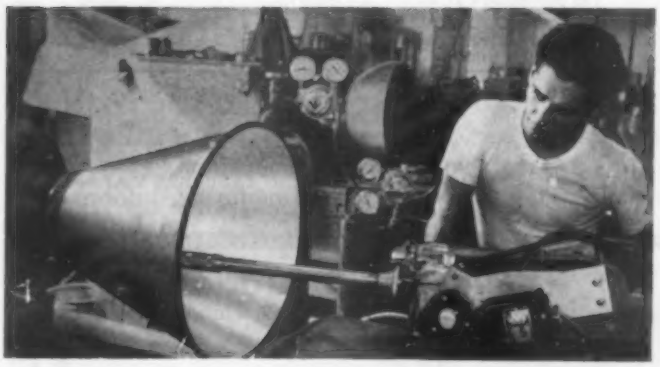

Now CDC offers *another* rocketry skill—Rokide heat-resistant spraying. The basic Rokide materials applied by CDC approach five times the hardness of stainless steel, have a much higher melting point, and are far lower in thermal conductivity and expansion.

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10	115	400	1	10,000	.05	.035	4.0	0.112 oz. in. at 6000 rpm	2.0 Oz.	....	10-A 8104-02
10	115	400	1	11,000	None (Shaded Pole)	.085	7.5	.096 oz. in. at 7000 rpm	3.5 Oz.	....	10-A 8101-01
11	115	400	1	12,000 Synch	0.1	.070	8.0	.08 oz. in. at 12,000 rpm	4.0 Oz.	....	11-A 8110-01
11	115	300-1800	1	10,000 (400 CPS)	0.5 (In Parallel)	.060 (400 CPS)	8.0 (400 CPS)	0.10 oz. in. at 9000 rpm (400 CPS)	5.0 Oz.	....	11-A 8223-01
11	115	400	1	60 Synch	0.1	.070	8.0	12 oz. in. at 60 rpm	7.75 Oz.	200:1	11-R 9003-02
11	26	400	1	30 Synch	2.0	0.35	8.0	14.5 oz. in. at 30 rpm	5.5 Oz.	195:1	11-R 9052-01
15	115	400	1	6,000 Synch	0.3	0.138	15.6	0.14 oz. in. at 6,000 rpm	8 Oz.	....	15-A 8120-01
18	115	400	1	12,000 Synch	0.35	0.148	14.7	0.41 oz. in. at 12,000 rpm	8 Oz.	....	18-A 8125-01
18	115	400	1	7600	0.6	0.45	4.5	2.45 oz. in. at 6800 rpm	24 Oz.	....	18-A 8126-01
18	115	60	1	8.5	1.0	0.175	17.5	30 oz. in. at 8 rpm	20 Oz.	405:1	18-R 9302-01
18	115	60	1	6.0	1.0	0.177	17.8	40 oz. in. at 5.75 rpm	20 Oz.	565:1	18-R 9302-02
21	115	400	1	22,000	1.0	0.75	80.0	1 oz. in. at 20,000 rpm	18.5 Oz.	....	21-A 8142-01
24	115	400	1	11,800	1.5	0.85	130.0	6.17 oz. in. at 10,800 rpm	29 Oz.	....	24-A 8161-01
24	115	60	1	20,000	None Required	1.2	175	8.9 oz. in. at 7,500 rpm	28 Oz.	....	24-U 8826-02
24	115	400	1	78	4.0	1.65	175	1530 oz. in. at 72 rpm	3 Lbs.	1528:1	24-R 9452-02
34	115	60	1	14,000	None Required	1.5	125	15 oz. in. at 4500 rpm	3-3/4 Lbs.	....	34-U 8901-02
34	115	60	1	1,780	3.75	0.45	50	12 oz. in. at 1700 rpm	4-3/4 Lbs.	....	34-A 8044-01

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ment of timing, our downgrading of the urgency of the situation and the inability to move ahead at the national level and get the job done.

Gen. Cook urged the United States to make maximum use of existing organizations, expand them where necessary and give them authority to move ahead immediately. The aircraft industry, he said, has the capability to provide manned satellites, anti-missile missiles and moon rockets within a very few years.

The AIA president is of the opinion that the basic commodity—a flying vehicle—has remained constant since the first manned flight 54 years ago. He says only the proportion of effort to each of the basic components (airframe, guidance, powerplant) has changed.

ABMA Trains AF *Jupiter* Personnel

The initial class of the Strategic Air Command's first *Jupiter* squadron has begun training at the Army Ballistic Missile Agency. Col. William C. Erlenbusch, commanding officer of SAC's 864th Strategic Missile Squadron, and key members of his staff arrived in Huntsville on January 15. It was the first contingent of Air Force personnel to begin training at the facility in preparation for assuming operational responsibility for the intermediate-range weapon.

The Air Force announced earlier this year that it expects to have the *Jupiter* in operational status late this year. The number of SAC personnel undergoing training at the north Alabama base is expected to increase as the agency becomes geared to handle the large number of trainees. The first class is expected to complete its training sometime in August and be ready to take the missile over completely.

Stauffer, Aerojet Join to Produce Boron Fuels

Aerojet-General Corp. and Stauffer Chemical Co. have announced a joint partnership agreement under which they will develop and produce boron-base fuels for rocket, missile and aircraft propulsion.

Initially, the major operation of the partnership will be investigation of manufacturing methods for high-energy fuels. Administrative headquarters will be located at Aerojet offices in Azusa, Calif.

Aerojet's background in boron fuel development, dating back to the early 1940s, will combine with Stauffer's experience in the basic boron raw materials and manufacture of

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boron chemicals. Stauffer last year completed the country's first large-scale plant for manufacture of boron trichloride, an intermediate in the production of boron fuels. Its West End Chemical Division holds a Federal lease on about one-third of the boron mineral deposits at Searles Lake, Calif.

Products Research Co. Creates New Divisions

Three new divisions have been formed by Products Research Co., a synthetic rubber firm. The new groups have been set up to serve different segments of industry and handle the increased demand for synthetic rubber compounds. The Industrial Division will serve the architectural, electronic and industrial concerns, while the Aircraft and Missile Division and the Marine Division will serve appropriate segments of industry.

Senators Hear Plea for *Titan* Production

The *Titan* ICBM should be ordered into production immediately to take advantage of the progress made to date. This was the view expressed by George M. Bunker, chairman of the board and chief executive officer of The Martin Co., at a recent Senate subcommittee hearing.

Bunker also urged that the United States "move full speed ahead into the full development of a program to take us into outer space."

Bunker was quoted as telling the Senate Preparedness Subcommittee that the *Titan* had proceeded very rapidly in its development stage but that he had been trying unsuccessfully for six months to get a production decision.

Sen. John Stennis, the subcommittee's vice chairman, in relaying the testimony later, said he was "surprised" that there had been no speedup in orders in the last three months.

The subcommittee also heard a report by George Trimble, head of engineering at Martin, on the *Vanguard* satellite's launching vehicle.

Third *Redstone* Unit Activated This Month

The Army's third operational *Redstone* unit, the 2d Battalion of the 333d Field Artillery, was activated at Fort Sill, Okla., February 1.

Activation of the 2d Battalion will be the initial step in the formation of another field artillery missile group (heavy) employing the *Redstone* missile. Forming the headquarters of the new missile group will be Headquarters and Headquarters Battery, 46th Field

Artillery Group, which is scheduled to move from Fort Bliss, Tex., to Fort Sill in late March.

When fully organized, the *Redstone* missile group will contain approximately 600 men and will include ordnance and engineer units as well as the basic missile unit. The Army activated its first *Redstone* group, the 40th Field Artillery Missile Group (heavy) in July 1957, at Redstone Arsenal, Huntsville, Ala. A second *Redstone* battalion, the 4th of the 333d Field Artillery, was activated at Fort Sill on Oct. 1, 1957.

Pentagon Tightens Reins On Industry Advertising

A new policy of closer review of industrial advertisements that features a military theme or a military product has been announced by the Pentagon. In making the announcement, the Defense Departmet cited excerpts from an Air Force regulation, 190-14, "Industrial Relations."

Points stressed in this regulation included: industrial advertising must not contain classified information, must be factually accurate, must not discredit the Air Force or state or imply AF endorsement of the product and must not contain AF specifications, test results and other data. The announcement noted that doubtful advertisements could be cleared through the director of information services. Ads and releases must be submitted in quadruplicate.

Sweden's *Jindiviks* Slated for Use in Missile Tests

Svensk Flygtjanst, the Swedish contract operator specializing in target flying for the Swedish Armed Forces, will also be responsible for operating the Swedish Air Force's fleet of *Jindivik* jet target aircraft. The *Jindiviks* reportedly will be based mainly in northern Sweden where they will be used for tests with new Swedish-developed SAMs and AAMs.

Schriever Testimony Reveals *Atlas-Thor* Costs

Maj. Gen. Bernard A. Schriever, chief, Air Force Ballistic Missile Division, ARDC, revealed in testimony before the Senate Preparedness Subcommittee the prices of the Air Force's production versions of the ICBM *Atlas* and the IRBM *Thor*.

Less launching and ground-handling equipment, the *Atlas* as an "assembly-line" item will cost $1.5 million each. This figure does not include the warhead. The equivalent figure for

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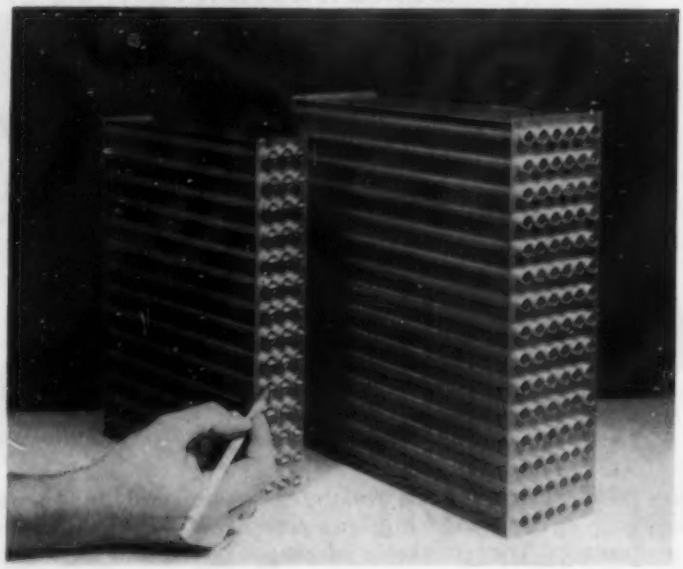

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Thor is $750,000. *Atlas* prime systems and production contract is held by the Convair Division of General Dynamics Corp. Douglas Aircraft makes *Thor*.

Gen. Schriever also revealed that the peak re-entry of the *Thor* is 15,000 feet per second.

Sputnik II Data

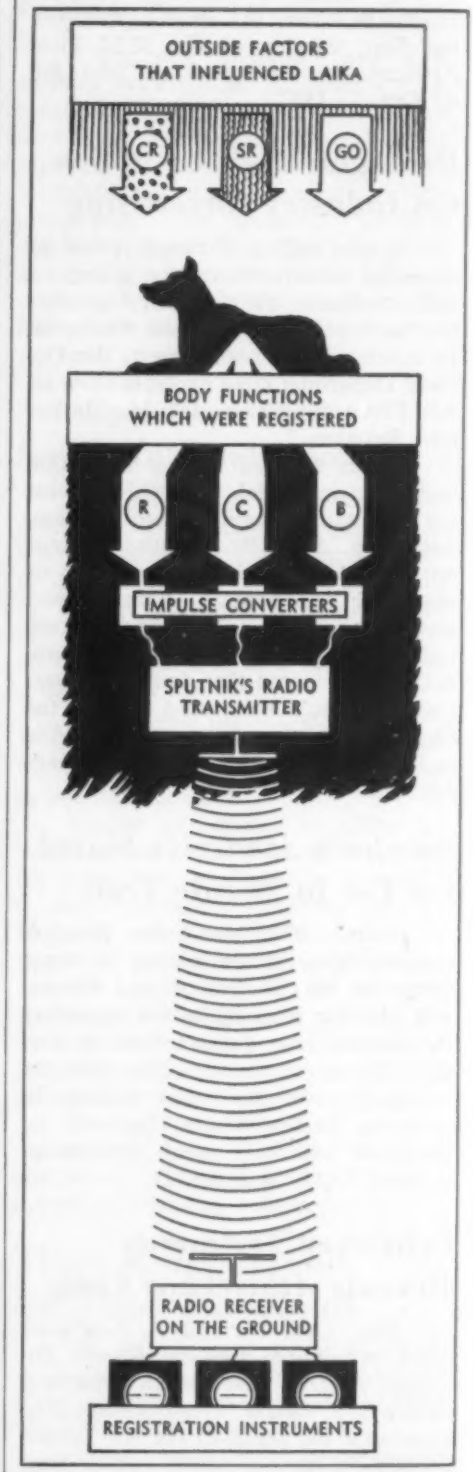

Diagram of medical and biological data sent by SPUTNIK II's transmitter shows influences of cosmic rays (CR), solar radiation (SR), and gravity zero (GO) on Laika's respiration (R), cardiac activity (C) and blood pressure (B) during the period of her life in orbit.

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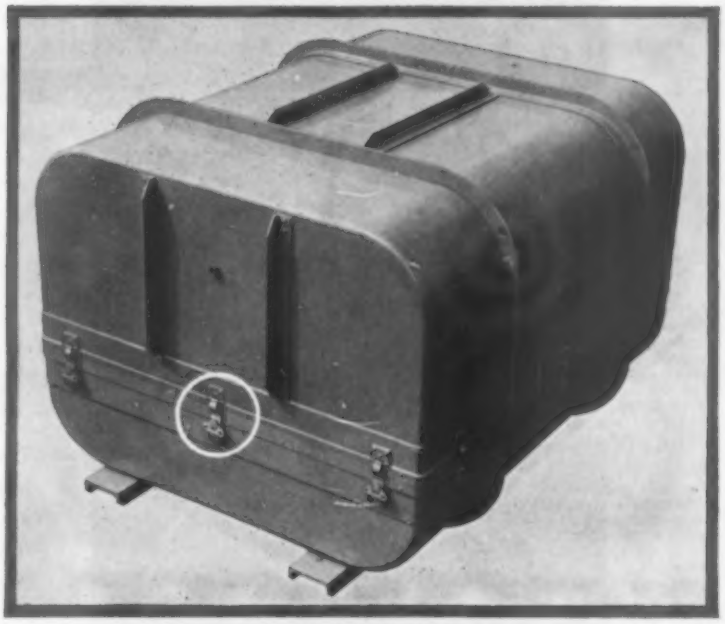
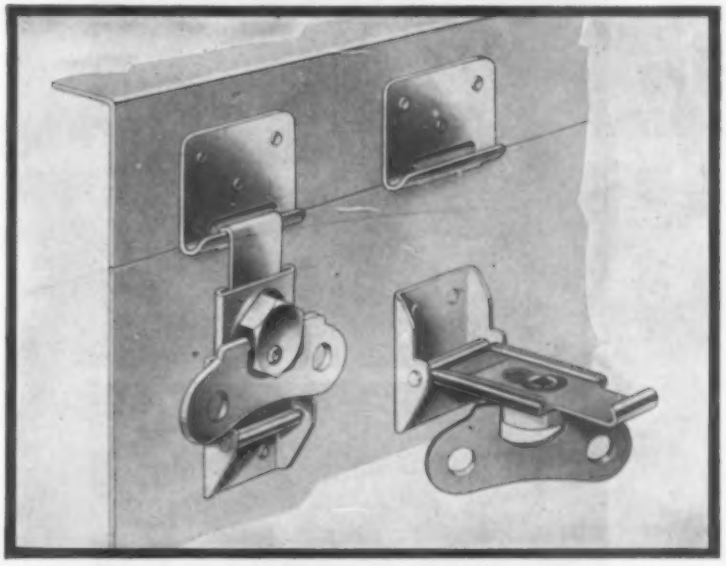


Twelve special loop-blade LINK-LOCK fasteners are used in this aluminum transit case designed by Applied Design Company.



Standard No. 2 LINK-LOCK (Medium-Duty). Available with screwhead, wing-nut as shown, or hex nut.

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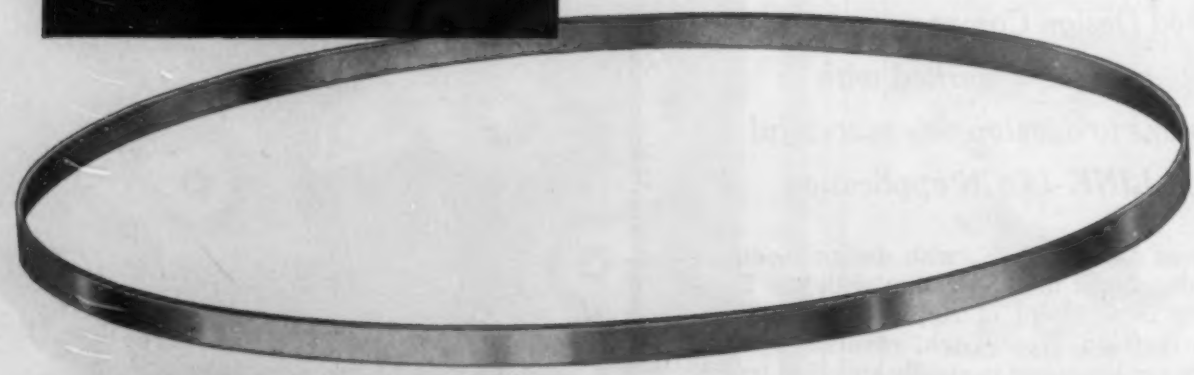
Precision Rings with little or no machining



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Criticism is Keynote of EIA Conference

Criticism of industry by the military, and vice versa, marked the Electronic Industries Association's recent conference on Maintainability of Electronic Equipment in Los Angeles, Calif.

However, if one problem in maintainability is "a lack of communication between the manufacturer and the customer," as asserted by several speakers, the difficulty should have been reduced considerably during the two-day session.

In the keynote speech, E. J. Engoron, representing the Office of the Assistant Secretary of Defense—Engineering, posed the services' problem of personnel, declaring that electronic maintenance must be "reduced to a design for the human actually doing the work, not the ones we'd like to have doing it.

"Out of all the electronic technicians in the service, 55 out of 100 are high school graduates, three out of 100 are college graduates," he said.

Designed-in maintainability is the only solution, he continued, noting that the military cannot achieve proper maintenance with in-service training since only 16 out of 100 electronic technicians reenlist.

"The DOD has a high stake in this work," he concluded. "The selection of a weapon over its competition may be based on its reliability and maintainability in relation to its capabilities. This philosophy will have a definite influence in future procurement."

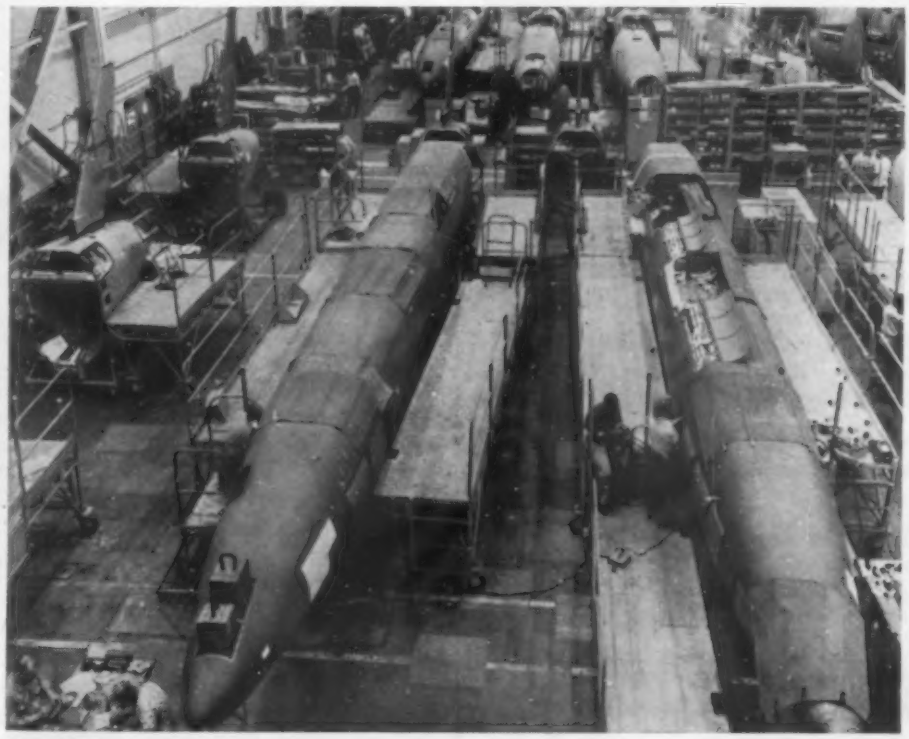
Also commenting on the subject of personnel, Brig. Gen. James Jackson, Deputy Commander of the San Bernardino Air Materiel Area, said that the technician is part of a "composite customer" and should not be made a "whipping boy" for the manufacturer's gripes on maintainability.

On the other hand, C. F. Horne, division manager of Convair-Pomona, noted that with the increased complexity of electronic equipment, "a screwdriver in the hands of an enlisted man is as good as a Russian bomb." He added that the problem of maintainability can be considerably reduced by use of "go, no-go" type tests.

In answer to a question by Navy Capt. W. E. Sweeney, director of BuAer's avionics division, concerning the varying degrees of effort in industry's quality control programs, Horne replied that management was still learning.

"Quality control must be in the hands of a top-flight man," he asserted, "not an old inspector," adding that quality control chiefs should not

Northrop's *Snark* Assembly Line in Operation



SNARK fuselage sections in various stages of fabrication move along assembly line at Northrop's Hawthorne, Calif., plant. First SNARKs will be based at Presque Isle, Maine.

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report to engineering or production divisions, but must be responsible to and backed up by "top men in the plant."

A quality control system depends upon a lot of things, Horne continued, but for the proper results a quality attitude must be present in engineering and production.

Col. G. G. Getz, chief, electronics-communications division, Directorate of Maintenance Engineering, Hq-USAF, admitted that the military agencies have "practices, procedures and red tape that must be modified, revised or eliminated."

Concerning maintainability, Col. Getz said the tendency to waive concurrent delivery of spare parts in order to put a piece of equipment into use as soon as possible creates a difficult maintenance situation.

"In some cases," he noted, "spare parts never catch up with the equipment."

Several speakers from industry complained about the lack of rigid, sufficiently detailed specifications from the military as to exactly what the services wanted in electronic equipment.

In reply, Col. Getz said that if electronic industries could put the specifications on paper as they think they should be, the military would see that they are put into bids and contracts.

The AF officer also said that he believed it was up to industry to develop its products on its own, not "stick us with a two-year contract for field service and maintenance plus parts."

Much discussion time was spent on when and how maintainability should be designed into a piece of electronic equipment.

"We don't necessarily build maintainability in," said J. D. McLean, president of Hoffman Laboratories, Inc. "It is generally neglected until it is almost too late to correct the damage. To do a good job, we must consider both maintainability and reliability in the basic [equipment] concept.

"But industry has a problem," he added. "With competition as it is, we have neither the time nor the dollars to do the job on the schedule required."

Asked if the military had considered maintainability problems in planning, Col. L. M. Reiser, chief of the Army's Signal Corps maintenance and engineering, said it had.

"We are depending upon the civilian technician for support until we freeze the design for production and train our people," he declared.

R. J. Shank, vice president, engineering, Hughes Aircraft Co., questioned the possibility of "freezing," but Col. Reiser said that in case of war, the design would be frozen so production could go ahead.

Gen. Jackson commented that "standardization must be avoided except for production blocks, as progress stops with standardization. The sky's the limit on design changes."

When asked by McLean if the services felt that they were getting more maintainable equipment by emphasis on a weapons system concept, Col. Getz said he felt they were.

"But it all depends on whether it does the job or not," he added. "We are not developing the capacity to handle the package completely. We might want to take it someplace the contractor can't go—what do we do then, put the contractor in uniform?"

The economics of a "throwaway" concept of maintenance came in for considerable discussion, but all were agreed that further investigation is called for in this field.

B. B. Troussoff of Bell Telephone Laboratories said that in the development of the *Nike-Ajax* system five years ago, the throwaway concept could not be considered, but

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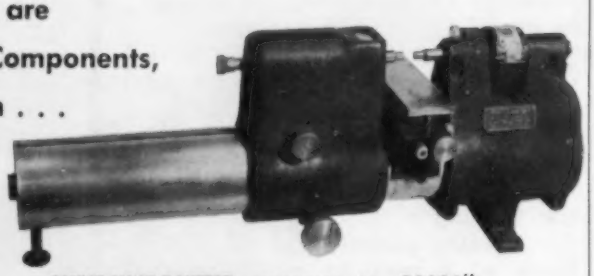

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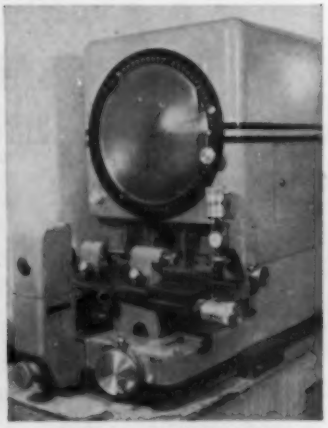

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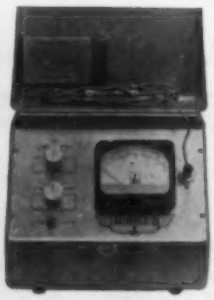

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"we might think differently today." However, he noted that the economics of this principle have not been investigated since the original *Nike* system was constructed.

Army missile systems came in for additional comment from C. I. Cummings, chief of systems engineering division at Cal Tech's Jet Propulsion Laboratories. Cummings said that the *Nike-Ajax* was "crashed into production before feasibility could be resolved."

"Personnel were so fascinated by the technical aspect," he said, "that they did not familiarize themselves with the system."

Cummings also expressed the opinion that the manufacturers were misleading Army Ordnance in some respects as to the maintainability of a system.

He said the Army is closely examining the maintenance and supply aspects of missile and electronics systems in general for incorporation in a complete logistics system such as MAMS (Modern Army Maintenance System) and MASS (Modern Army Supply System). It may be possible to replace maintenance with supply in the throwaway concept if a satisfactory division of assemblies or a piece/part system is worked out at a realistic cost.

The conference brought forth some fairly sharp opinions from both the military services and industry, but, in general, most of those attending expressed the opinion that the "off-the-chest" remarks provoked some serious thinking on problems of maintaining modern, ultracomplex electronic equipment.

Boeing Delivers Production *Bomarc*

The first production model of the *Bomarc* IM-99 missile has rolled off the assembly line in Seattle seven months after the awarding of a $7-million contract for tooling-up operations. An inventory production contract for $139.3 million was awarded Boeing last August.

The first firing of a *Bomarc* was made from Cape Canaveral on September 10, 1952. This flight was far from successful. The missile performed a double loop about a hundred feet in the air and crashed to earth a few feet from the launching pad. In a recent test a *Bomarc* intercepted and destroyed a target drone at a range of more than 100 miles and at an altitude of more than 60,000 feet.

The delivery of the first production model marked the beginning of a program designed to supply the missiles and associated weapon system

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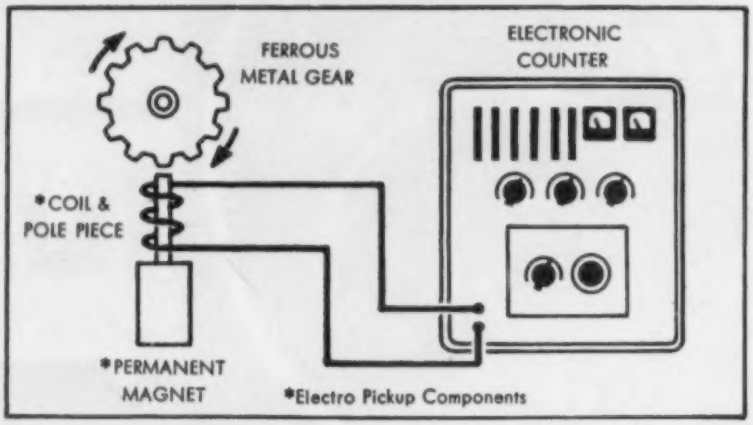

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b Feed output of Magnetic Pickup directly to electronic counter. Set counter to count for a suitable time—such as 1 second (1/60 minute).

$$RPM = \frac{\text{Displayed count} \div \text{pulses per rev. (no. of teeth)}}{\text{counting time (minutes)}}$$

Accuracy depends on three factors:

1 Accuracy of the counter (usually ± 1 digit).

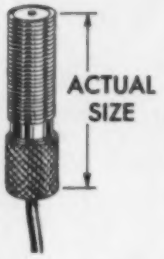
2 Length of counting time.

3 Number of pulses per revolution.

Example:

60 tooth gear providing 60 pulses per revolution with a count of 1 sec. (1/60 min.) will produce an accuracy of ± 1 rpm at *any* speed. (counter reads rpm directly with this set-up). If counting time is increased to 10 sec., accuracy will be ± 1/10 rpm.

Sub-Miniature 3055



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equipment to selected bases in the United States. The Air Force recently announced the acquisition of land for four *Bomarc* bases in the northeastern part of the United States and an operational testing and personnel training base on Santa Rosa Island near Eglin AFB, Fla. First production *Bomarc*s will be delivered to the Santa Rosa base. The other sites will be located near McGuire AFB, N.J.; Suffolk County AFB, N.Y.; Dow AFB, Me., and Otis AFB, Mass.

The first production BOMARC IM-99 surface-to-air missile is rolled from the assembly line in Seattle. The rollout marked the beginning of the AF area defense buildup.

Thiokol & Callery Combine Solid Efforts

Thiokol Chemical Corp. and Callery Chemical Co. have combined their efforts for the production of high-energy solid-propellant powerplants. Callery will produce the solid fuel and Thiokol will develop the rocket motors.

Callery recently announced the development of HiCal, a high-energy boron-based liquid fuel. This new fuel is currently being used in the development of new rocket propellants at Thiokol's Elkton and Redstone divisions.

J. W. Crosby, President of Thiokol, in announcing the working arrangement with Callery, said, "We feel that the greater energy possible from this type of fuel will help us to achieve a rocket motor of greatly improved performance with lower weight and greater power. Preliminary studies with this new fuel have been encouraging."

The HiCal fuel, in solid form, will be combined with oxidizers and used in the case-bonded rocket motor design. Appreciable production of the new fuel may be a few months away. Callery, while announcing plans to produce HiCal, emphasized that pilot quantities of the fuel will not be available for large-scale rocket tests until later this year.

Callery recently formed a solid fuels group at the company's Research

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Unusual forging solves Falcon design problem!

MISSILE BY HUGHES AIRCRAFT

Upset Forging by Commercial Shearing!

The JATO nozzle for the Hughes Falcon air-to-air guided missile presented some difficult metal forming problems.

Hogging it out of a cylindrical blank would involve considerable machining time and wasted material. Commercial engineers working with Hughes during the developmental stages of this missile produced an upset forging with a through-pierced hole of varying diameters involving tapers at both ends. The internal displacement method refines the grain and eliminates hidden flaws in the metal, assuring greater strength of the finished part.

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and Development Division, Callery, Penna. Liquid HiCal will be produced at a $38-million Navy plant at Muskogee, Okla., and at the $4-million company-owned plant now under construction in Lawrence, Kansas. The Lawrence plant is expected to start limited production this spring and the Muskogee plant early in 1959.

Dual Thrust Motors Now Under Development

Conventional multistaged boosters and sustainers offer difficulties, says R. S. Newman of Aerojet-General Corp. The droppable booster is a hazard and ignition and separation have to be synchronized. The dual thrust motor is now under development and is said to eliminate these troubles.

A current method uses one or two propellants in a single case to give different thrust levels. Work on a tandem motor, started in 1953, allows the sustainer propellant to fire directly into the booster case. The pressure and, hence, thrust are increased. A novel method eliminates the higher pressure of the tandem motor by the use of a blast tube and separate nozzle.

Configuration similar to these described may be slated for use in a version of the *Polaris* prototype missile.

Lockheed *Polaris* Funds May Double in '58

Anticipated contract awards, designed to accelerate the *Polaris* fleet ballistic missile program, are expected to bring the Navy funds allocated to Lockheed's Missile System Division to approximately $130 million.

This figure will include original funds allocated for the initial research and development of the project, $62.1 million for fiscal year 1958 awarded last October, and the newly planned contracts. Also included is money destined for distribution to subcontractors. The additional funds will nearly double the amount of 1958 fiscal year funds available to Lockheed for expediting development of the *Polaris*.

The initial impact of the increase would be felt in technical areas with a resultant advancing of all dates in all areas of the missile's development. Missile development is being performed at the research, development and production facilities at Sunnyvale and Palo Alto, Calif., at testing facilities in the Santa Cruz Mountains, and at Cape Canaveral, Fla.

Lockheed, in addition to being missile system manager and developer of the *Polaris*, is providing management for the testing phase, and conducting a Navy training program.

NAA & Phillips to Form Rocket Motor Firm

Astrodyne, Inc., a new company to specialize in the missile solid-propellant rocket motor field, will be formed by North American Aviation and Phillips Petroleum. The company will be jointly owned by Phillips and NAA and will unite their activities in the research, development and manufacture of high-energy solid fuels, propellants and devices for use in rocket motors and missile systems.

Astrodyne, Inc., will locate its headquarters and operations at AF Plant 66 near McGregor, Texas. The Phillips plant has been in operation since 1952 conducting solid-propellant research, development and manufacturing. JATO solid-propellant motors are currently being produced at the plant, which employs about 900 people. The completion of some of Phillips' contracts with the Air Force is expected to result in a temporary slackening of operations at Plant 66. According to company officials, this situation will exist only until the Astrodyne plant has started operations.

Cosmic Rays No Problem, Swiss Professor Claims

Cosmic rays will not be a problem in space travel, according to Dr. Frederic Houtermans, head of the physics department at the University of Bern, Switzerland.

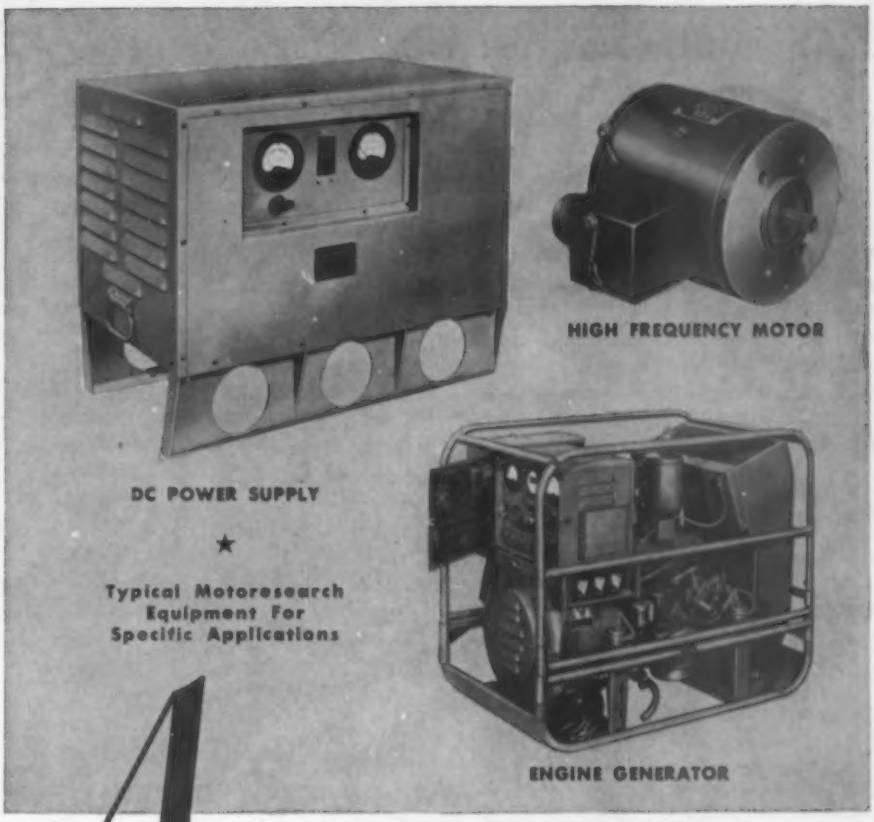
Lecturing on geochemistry at the California Institute of Technology, the Swiss physicist stated that space voyagers will be subject to radiation doses well within the recently revised AEC limits of not more than 15 rems per year.

He pointed out, however, that cosmic rays may reach a dangerous intensity during sun flares, but the cyclic frequency of such flares poses no serious problems.

Basing his findings on methods he and his colleagues use to study the effects of cosmic ray bombardment of meteorites, Dr. Houtermans estimates cosmic radiation in outer space by measuring the radioactivity of tritium in meteorites through a thermoluminescence process.

As a result of the studies, he said, there is some indication that a satellite re-entry problem might be solved by enclosing the vehicle in a lightweight material that would burn off during the fall to earth.

He cited the temperature increase of a meteorite "skin" as only 392°F during its descent through the atmosphere.



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AAS Holds Largest U.S. Space Meeting

Forty original technical papers on various aspects of space flight were presented at the three-day annual meeting of the American Astronautical Society last month. Held January 28 to 31 at the Engineering Societies Bldg., New York City, this meeting was the largest such U.S. presentation on astronautical matters ever held.

There were six technical sessions co-chaired by such well known astronautical personalities as Col. Paul A. Campbell (MC), USAF; Mr. Robert P. Haviland (MOSD, General Electric); and Mr. William C. House (Aerojet-General).

Subject coverage ranged from space-medical and cabin-environmental problems to propulsion, guidance, communication, attitude control, flight paths and navigation in space.

Among the papers presented were "Returning Alive from Space," by F. Riddell and R. Detra, Avco Research Lab.; "Hydrogen Peroxide as a Source for Oxygen, Water, Heat and Power for Space Travel," by Noah S. Davis, Food Machinery & Chemical Corp.; "Problems of the Environment of Space Ship Occupancy," by William T. Ingram, New York University, College of Engineering.

Others included "Isolation and Confinement in Space Flight," by Capt. G. E. Ruff (MC), USAF; Capt. E. Z. Levy (MC), USAF, and Capt. V. H. Thaler (MC), USAF; "The Selection and Training of a Bio-Satellite Crew," by D. W. Conover, E. G. Aiken and G. M. Whitlock, Convair-San Diego; "Space Cabin Design," by A. M. Mayo, Douglas Aircraft Co.; "Beryllium Applications in Thermo Structural Design," by R. E. Foster and L. A. Riedinger, Lockheed Missile Systems Division; "Plasma Motors," by Winston H. Bostick, Stevens Institute of Technology.

Also presented were "A Solid-Propellant Propulsion Vehicle for Lunar Exploration," by Frank A. Marion, Don F. Billhardt, Grand Central Rocket Co.; "Potential Application of Nuclear Energy to Space Vehicle Propulsion," by C. J. Wang and G. W. Anthony, Ramo-Wooldridge Corp.

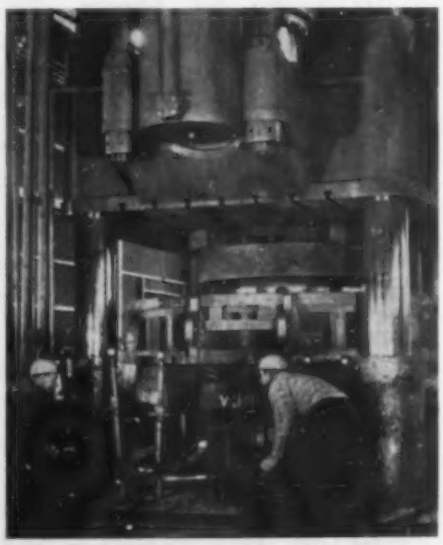
Other prominent authors included Dr. Hubertus Strughold, USAF School of Aviation Medicine; Dr. Herman Schaefer, USNAS, Pensacola; Cmdr. George Hoover, USN; Dr. Angelo Miele, Purdue University; Jorgen Jensen, Martin Co., and Cmdr. Malcolm Ross, USN, ONR.

Lukens Steel Press Forms Ballistic Cones

Nose cones for the *Atlas* and *Thor* missiles are being formed by a large hydropress capable of exerting a force of up to four million pounds.

Lukens Steel Co., subcontractor to General Electric's missile and ordnance systems department, is forming the rought nose cones from heavy steel plate with a four-post hydraulic press.

This is a first disclosure on fabrication techniques employed in the nose cone program. The rough formed cone, as removed from the press, is probably machined to finish tolerances before the heat-resistant ceramics are applied. The hydraulic-press technique of forming will be readily adaptable to a capacity production schedule. GE's MOSD holds the *Thor* and *Atlas* nose cone development contract.



A four-post hydraulic press at Lukens Steel Company is shown in closed position during the shaping operation on the nose cones for the ATLAS and THOR long-range missiles.

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Chrysler Hiring 4000 For *Jupiter* Production

The decision to place the *Jupiter* IRBM in production at Chrysler's Warren, Mich., plant has created a demand for an accelerated personnel recruitment program in the Detroit area. Chrysler will add 4000 employees during 1958, at the rate of about 100 a week, to work on the *Redstone* and *Jupiter* programs.

The hiring program calls for about 25 per cent qualified engineering personnel, 40 per cent qualified technical personnel, with the remainder ranging from highly skilled to unskilled. Many of the latter will possibly be hired from the automotive industry personnel currently unemployed in the Detroit area as a result of a major layoff.

Rocketdyne Reveals Its *Redstone* Engine

CANOGA PARK, Calif.—The Rocketdyne division of North American Aviation, Inc., has shown off its *Redstone* rocket engine. The single-chambered engine delivers over 75,000 pounds thrust through combustion of liquid oxygen and alcohol. The latest version weighs less than 1450 pounds and is 10 feet, 11 inches long, and 5 feet, 10 inches in diameter. Hydrogen peroxide drives a 780-horsepower turbopump. The gas generator unit is small and light enough to be held in one hand.

The regenerative-cooled engine operates at over 5000°F with the alcohol fuel circulating around the chamber. The engine was first tested in 1950 and first production began in 1952. The ruggedness and reliability of the engine, now going to the Army and Chrysler, is demonstrated by the fact that as many as 10 consecutive full-duration, full-power runs were made with single-engine assemblies.

Army Ballistic Missile Agency personnel at the Redstone Arsenal, Huntsville, Ala., remove rocket engine for REDSTONE missile. Thoroughly tested before shipment, the engine goes through another test firing before its installation on the missile at ABMA.

Rocketdyne Constructs Engine Service Center

The Rocketdyne division of North American Aviation, Inc., is constructing with private funds the first rocket engine service center. The new center will support future Air Force units of *Atlas, Thor* and *Jupiter* ballistic missiles. The engines for these missiles were developed and are being produced by Rocketdyne.

The center will include a corps of field engineers, a factory-to-field spare-parts group, and an overhaul plant. The facility, which will provide 132,000 square feet of office and factory space, will cost $1.5 million. Total service personnel strength is expected to number nearly 1000 by mid-year. Completion of the center is scheduled for this fall.

The first Air Force ballistic mis-

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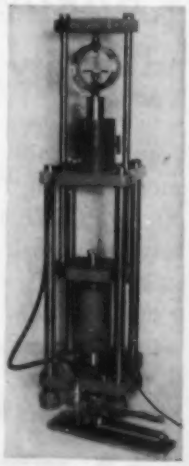

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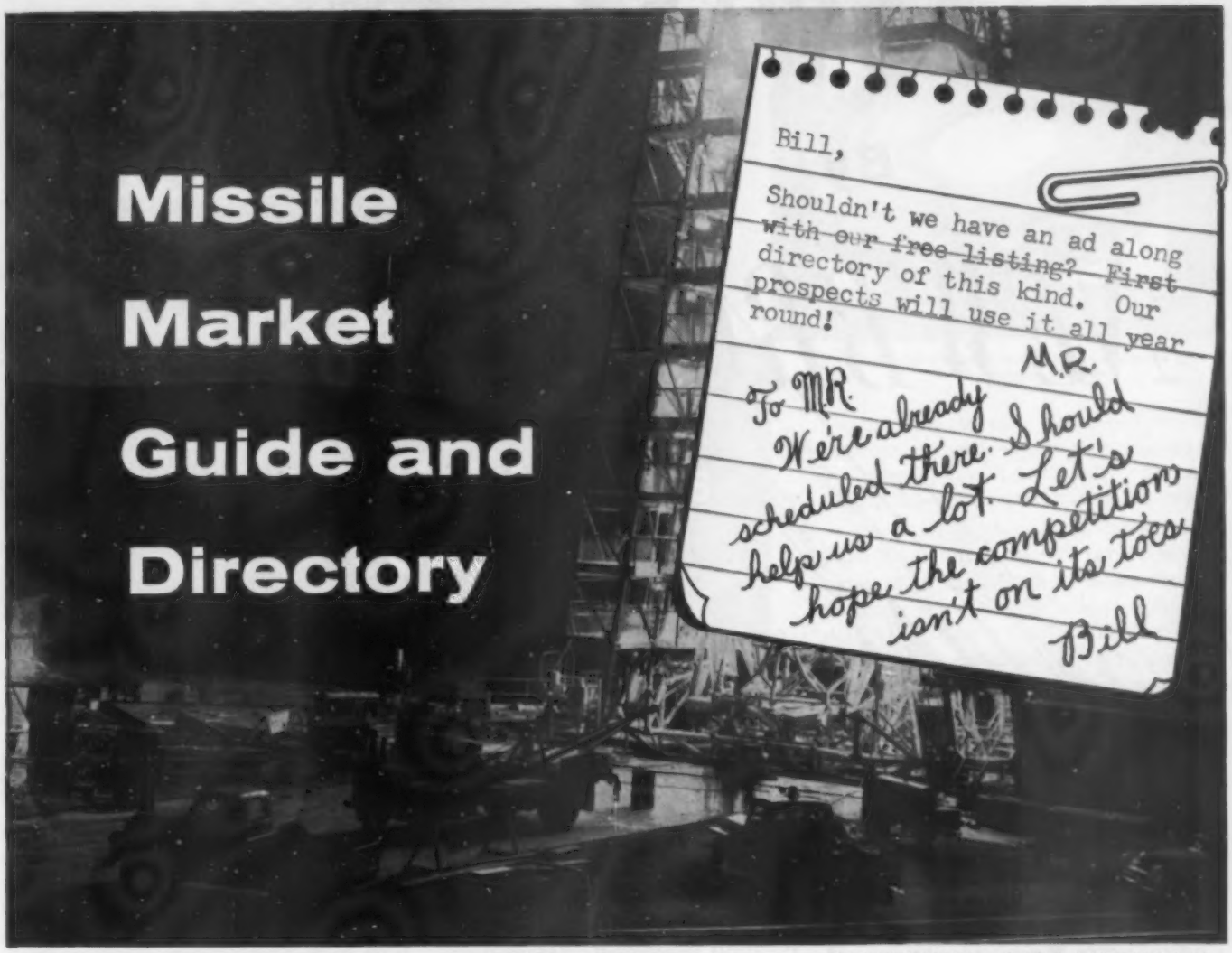
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sile units to be serviced by the Rocketdyne center are the recently activated 672nd and 864th Strategic Missile Squadrons for *Thor* and *Jupiter*.

RRI Static Tests *Spark* Research Engine

SACRAMENTO, Calif.—*Spark* IA, a civilian-constructed, unclassified, 400-pound-thrust liquid-propellant rocket engine was successfully fired recently

by the Sacramento section of the Rocket Research Institute. The engine burned for 25 seconds on watered alcohol and LOX. The training rocket was tested at nearby Elk Grove, Calif.

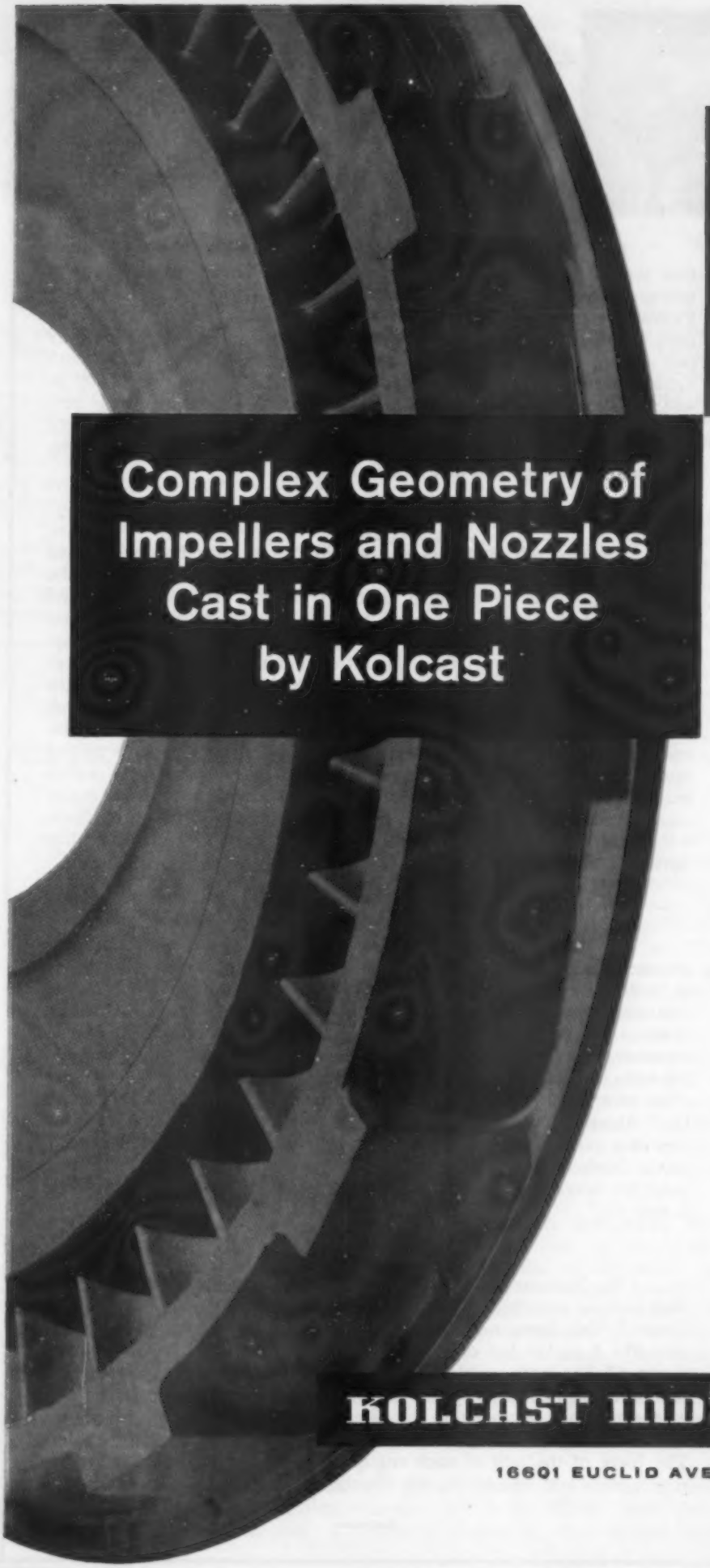
The *Spark* engine is slated to go into an intermediate-altitude (over 100,000 feet) rocket to be used during the IGY in Nevada tests by the RRI. The institute aims to make such liquid rocket engines available for rocket groups and schools.

Elgin Watch Moves Electronics Headquarters

The electronics division of Elgin National Watch Co. has established new headquarters in the company's former military fuze plant.

The new plant becomes the administrative center for electrical relay production sold under the Advance and Elgin names. Much of the relay production has been for military electronic equipment, but sales to the industrial and commercial fields are also being emphasized.

Just prior to World War II Elgin acquired the headquarters plant, which became a center for military fuze production during the war.



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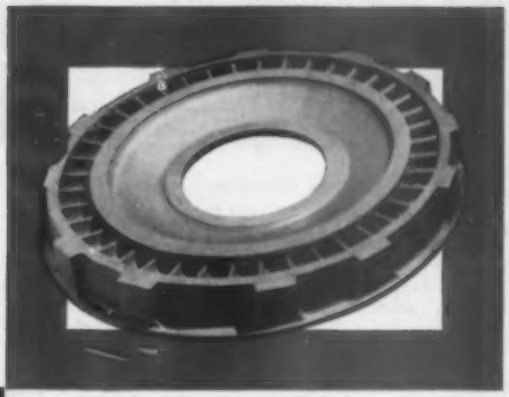

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Soviet Affairs

by Dr. Albert Parry

The American assertion in the wake of our *Vanguard* failure that the Soviets must have had their quota of similar misfirings, was countered by Academician Leonid I. Sedov. Writing in the Moscow PRAVDA, Sedov announced: "We in the Soviet Union have never had any unsuccessful attempts of launching the earth's artificial satellites. Only two attempts were made, and both were successful." The success of both *Sputnik* firings, he explained, was the result "of the thorough way in which all the preliminary work had been carried out." In such preliminary preparations all the "individual elements" of the project were "tried out, studied and checked," and "the total system of the launching was thought through and analyzed in detail."

•

Some of our engineers and manufacturers may be disappointed with titanium as the wonder metal for our supersonic planes, but the Russians appear to be as much impressed by this lighter-than-steel and tougher-than-aluminum commodity as ever. The Soviet government has just revealed that its geologists and engineers recently completed appraisal of that country's largest deposit of titanium. This latest discovery is located on the right shore of the Dnieper in the Ukraine, along the Samotkan, a minor tributary of that river. Together with titanium, much zirconium has also been discovered there. Both lie at shallow depths, and this, according to the Soviets, permits less expensive strip mining instead of tunneling. Our disappointment in titanium stems from certain bugs in its use for supersonic aviation. As one American titanium expert said: "It draws gases to it like flies to flypaper. And the strength-to-weight ratio is not everything it's cracked up to be." Could it be that Soviet titanium specialists have licked these two bugs?

•

Russian technocrats are inventive, but Russian bureaucrats are obstructive. So, in effect, complains A. Garmashev in the recent IZVESTIA, as he divulges that "as of July 1, 1957, more than 4000 Soviet inventions remained unused." Garmashev is chairman of the Committee on Inventions and Discoveries attached to the Council of Ministers. He blames bureaucratic backwardness in a number of Soviet industries for preventing utilization of those inventions. Two days earlier, the Moscow TRUD cited an appalling example of just such hampering and hindering at the Ural Aluminum Works. Out there, an ingenuous and practical invention of a quick cleanser for gas pipes was stubbornly rejected by bureaucratic chiefs on the ground that "its introduction would require a considerable investment of money, yet we really don't know what good it may do."

•

To SOVETSKAYA AVIATSIA, candidate of technical sciences V. Aleksandrov contributes an article on "Rocket-Plane, the Plane of the Future." This flying machine, he maintains, "will be launched into cosmos like a rocket but on returning to earth will land like an ordinary airplane." The main problem yet to be solved, according to Aleksandrov, is how to change the direction of the rocket-plane's flight at will. "One of the methods of changing the direction," he writes, "may be the use of additional rocket engines placed at an angle to the flight's direction. The force of the pull of such engines will change the trajectory of the rocket-plane's movement in the direction desired."

Moscow Briefs

The December 1, 1957 edition of the newspaper SOVIETSKAYA AVIATSIA carried an interesting illustration of a rocket-plane trajectory. The pattern was strikingly similar to that which appeared in the February 1957 issue of m/r. The illustration in SOVIETSKAYA AVIATSIA, however, shows the trajectory over territory of the USSR and ending close to the South Pole.

V. Alexandrov, candidate of the technical sciences, says it is "the airplane of the future" and after achieving speeds of 12 to 15 thousand kilometers per hour (about 7500 to 9300

miles per hour), the pilot will switch off the engines and glide along the top of the earth's atmosphere to his destination. The rough diagram shows the craft being launched vertically to an altitude well above that considered necessary for the job.

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Radio Moscow has made repeated references to a "graviplane" which will enable man to make extraterrestrial flights "without the aid of rockets."

•

Project Boomerang, the USSR's effort to place an instrumented vehicle in an elliptical orbit around the moon, has been placed under the direction of Prof. G. A. Chebotarev. A doctor of "physico-mathematical" sciences with the Leningrad Institute of Theoretical Astronomy, Chebotarev authored a paper in February 1957, giving considerable technical detail on the method of placing a payload of 110 to 220 pounds in a lunar orbit. The paper was entitled "Cosmic Boomerang," and exhorted Soviet engineers and scientists to begin work on a project such as that outlined in the paper.

•

An unmanned "radioteledirected" rocket for probing interplanetary space is understood to be under development by a team of Soviet scientists under the direction of Iu. S. Hlebtsevich. The rocket is scheduled for completion and launching "in the near future" and will, of course, precede other Soviet vehicles into space. The rocket's first destination was not indicated, but frequent references to project *Boomerang* (see above) hint that this may be the vehicle to carry out that mission.

•

Intercontinental rockets of the the future will have wings that will make them look like large economy-size versions of today's airplanes. So declares Georgi I. Pokrovsky in the newspaper SOVIETSKAYA AVIATSIA. The author, an expert in intercontinental ballistics, predicts that "further development of cosmic flights will lead to a rapprochement between the technology of rocketry and that of aviation. For instance, the problem of creating a spaceship that would return to earth can be solved only by giving this ship a system of wings and guidance peculiar to our contemporary airplanes."

•

The Red Army newspaper, RED STAR, published a map of NATO dispositions in its issue of December 14, 1957. The map shows staff headquarters for the operations areas of NATO, and the alleged number of divisions assigned to various areas. The establishment of missile launching sites has been receiving coverage in the Soviet press, as has President Eisenhower's "war budget."

•

Heavy fuels are being experimented with in the USSR. Such specimens as furnace oil, shale oil and shale tars are being tested at scientific centers as possible sources of rocket power.

•

Soviet scientists, nominally above politics and the state for the good of mankind, are being continually reminded that they are *Soviet* scientists first and foremost. Writing in the party journal KOMMUNIST and the journal of the Academy of Sciences of the USSR, the Central Committee of the Communist Party told the Academy members that, "Our scientists cannot and must not stand aside from the ideological struggle between communism and capitalism. The time has supposedly arrived when we can allow ourselves such an existence of two ideologies. This is a deeply mistaken deduction; this is what our ideological enemies want—namely, ideological disarmament of the Soviet Union. Now, more than ever, uncertainty, neutrality, political indifference, against which V. I. Lenin always spoke, cannot be tolerated in our midst." The reminder was written by A. Topchiev, chief science secretary of the Presidium of the Academy of Sciences and a Communist party member for 25 years.

•

The magazine USSR, a Soviet publication distributed in the United States, notes "an interesting phenomenon" which occurred during the radio transmissions of *Sputnik* II. During the passage of the satellite near the area of maximum ionization of the atmosphere, radio signals from the satellite were received—not by the shortest distance, but after the waves had traveled around the longer side of the globe.

•

Prof. Kyril Stanyukovich, a Soviet physicist, was quoted by Radio Moscow as citing the great advantages to be gained by sending a camera-equipped satellite around the moon to photograph the surface. In addition to still and motion picture cameras, there are plans formulating to put a television camera in such a satellite. No mention is ever made in such programs to use of such satellites to photograph the earth for military purposes.

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Space Medicine

by Hubertus Strughold, M.D., Ph.D.

Approximately 450 people took part in the symposium on human factors sponsored by the American Rocket Society on December 4, 1957, at the Hotel Statler in New York. Among the speakers were Maj. David G. Simons of Holloman Air Force Base and Otto Winzen of Winzen Research, Inc. Together they gave their first report on Project *Man High*, the balloon flight in which Dr. Simons attained an altitude of 102,000 feet.

At the same meeting, Cmdr. C. C. Brock, from the Office of Naval Research, delivered a paper on "Space Flight in the Undersea," emphasizing the similarity with regard to human factors between space flight and cruising in a submarine, for example under the Arctic ice cap. He noted that a conventional aircraft and a spaceship are cousins, whereas a spaceship and a long-range submarine like *Nautilus* are brothers.

My comment: Let's name the first true spaceship *Astronautilus*.

•

At the annual meeting of the Aeromedical Association, to be held March 24, at the Hotel Statler in Washington, D.C., Col. Paul Campbell of the Air Force Office of Scientific Research will conduct a symposium on space medicine. Among the topics to be presented are specific problems such as cosmic rays, life at "the boiling point," high-altitude bailout from balloons, and weightlessness.

•

Studies on the use of plants to regenerate air in a closed ecological system, such as that of a space cabin, have been carried on for several years at the University of Texas by Dr. Jack Myers, Department of Algal Physiology, and at the School of Aviation Medicine, Randolph AFB, Texas. Certain algae, dispersed in a nutrient solution and exposed to light in order to induce photosynthesis, have been examined for their efficiency in this respect.

The work began with the blue-green alga, *chlorella pyrenoidosa*, a tiny round organism only a trifle larger than a red blood cell. It was found that about five pounds fresh weight of this species are sufficient to provide one man with a continuing supply of oxygen and to absorb his excess carbon dioxide.

Recently, another, much smaller, microorganism resembling a bacterium, *anacystis nidulans*, has been tested. It is much more efficient. Only one and one-half pounds suffice for the respiration needs of a single man. At the present time, mice are being kept alive in a closed system using this alga.

•

The 13-week series of educational television programs on space medicine called "Doctors in Space," which has been mentioned before in this column, had its national premiere on January 5. The half-hour programs, financed by the Ford Foundation and produced by the University of Houston, were written by Green Peyton, Chief of Information Services at the School of Aviation Medicine. Distributed by the National Educational TV Center of Ann Arbor, Mich., they will continue through March on educational stations and others which will carry them as public-service presentations.

•

Of all the specialties and branches of medicine, space medicine is the only one that deals with cosmic subjects, such as astrophysics, celestial mechanics and planetology. In Russian literature, space medicine is known as cosmic medicine.

World Astronautics

by Frederick C. Durant III

Look for THE RACE FOR SPACE at your newsstand this month. Offbeat and fulminating, it is a collection of stimulating and controversial articles on the lagging position of the United States in science education and space operations. Edited by Paul G. Neimark, the price is $1.00.

The collection has some faults. There are irritating typos, a few obvious technical *faux pas* and it is hodgepodge. But it is fun reading the hard-punching (if occasionally anarchistic) prose. The theme may be judged from the following Q's and A's which appear on the back cover: *Where do we stand?* Second. *What can we do?* Much. *What if we don't?* We must.

Many of the authors are well known. Here are some quotes from the contents. "The public must realize that the choice is not between *living* and *living well*, but between *living* and *ceasing to live*." (NBC commentator Clifton M. Utley); ". . . Perhaps the race is not worth running, but let us not kid ourselves that we can win it in second gear . . ." (nuclear chemist Herbert H. Hyman); and this wonderful blast by aeronautical engineer and writer L. Sprague de Camp: "It is absurd to say that the fat, dumb and happy American people cannot afford higher taxes. To overtake the Soviet Union in science, a lot of my softheaded countrymen must be convinced that it is more important to support research than to give senseless handouts to anybody who ever plowed a furrow or wore a uniform. . . . Let the program be paid for either by higher taxes, like those we had in the Hitlerian War, or by starving our sacred cows—veterans, farmers, highways and dams in the desert. Or, better yet, by both." Others include former GE President Charles E. Wilson, science writer Isaac Asimov, TV personality Mike Wallace, author James T. Farrell, Willy Ley and Carl Sandburg.

•

Science writer Arthur C. Clarke in a piece in the newspaper Sunday supplement, THIS WEEK, draws a neat analogy between 15th Century Venice and the current dawn of the space age. At that time Venice was mistress of the seas—the unchallenged ruler of the maritime world. The trade routes across the western ocean beckoned and men of vision looked for sponsorship.

But the Venetian rulers were not interested. For centuries "the commerce of half the world had paid them tribute—why should they be bothered with wild adventures in unknown seas? They made their choice. They chose to stay with the old and comfortable ways of doing things." We all know the outcome. The explorers sought encouragement elsewhere and within a generation "the riches of the new world were pouring into Spain and Portugal. The tide of wealth and power ebbed from Venice, never to return." There is a lesson here that is plain.

Clarke goes on to point out the finality of the challenge which now confronts the Western World and states unequivocally, "We shall not survive if we are lazy, soft or complacent."

•

The Ninth Annual Congress of the International Astronautical Federation will be held in The Netherlands (either in Amsterdam or The Hague) August 25-30. It is not too early to start thinking of travel plans. Increasingly, industrial and DOD establishments have been recognizing the appropriateness of professional representation at IAF Congresses.

If you are interested in submitting a paper, action should be taken within the next few weeks. Contact Krafft Ehricke of Convair-Astronautics, San Diego, Calif., for ARS sponsorship, or Norman Peterson, Sperry Gyroscope Co., Sunnyvale, Calif., for AAS sponsorship of your paper.

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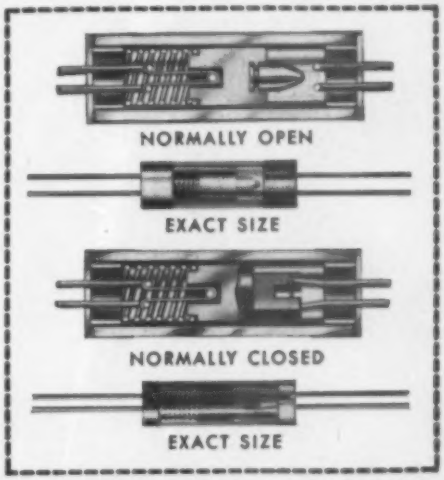

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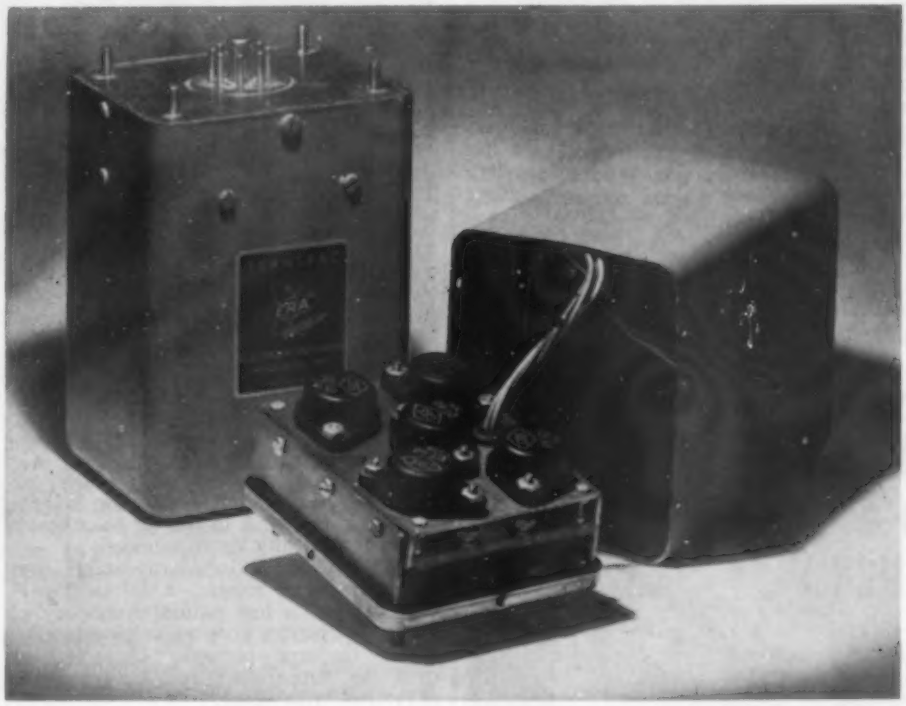


TOGGLE SWITCHES

A new series of toggle switches featuring an integrally designed lever lock and requiring a definite pull of approximately .09" to change lever positions is now available from Micro Switch Division of Minneapolis-Honeywell.

By insuring positive switching, the lever lock prevents false actuation by objects snagging or hitting the toggle lever. Designated the "TL" series of "pull-to-unlock" toggle switches, the switches have integral terminals, offering easier wiring and stronger connections. A step-design case allows more space between terminals, minimizing the possibility of shorting.

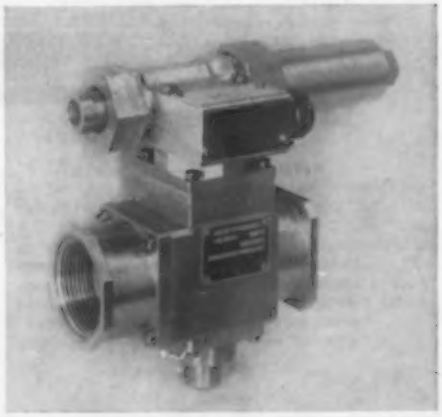
The toggle lever itself is oversize and has a knob on the end. Changing the toggle lever from one locked position to another is not difficult even when one is wearing heavy gloves. The "TL" series of toggle switches is available with 11 different toggle-locking positions and in three circuitry types—single-pole, double-pole and four-pole. They are rated electrically at 20 amperes, 30 vdc, resistive load.

Circle No. 217 on Subscriber Service Card.

SHUTOFF BALL VALVE

Designed by Progressive Research and Development Corp. for concentrated hydrogen peroxide or red fuming nitric acid, these valves are suitable for airborne rocket operations. The straight-through flow of the system media produces a pressure drop equal to that of an equivalent length of tubing when the valve is open. The valve operation requires no lubricant and a hydraulic device in the actuator provides a time-adjustable slow-opening feature and still retains a rapid spring-closing action for fail-safe operation.

An electrical position indicator can be provided to indicate valve position remotely, the indicator circuit being connected through an "AN" electrical pin receptacle mounted on the valve actuator. The valves also feature double dynamic seals with an overboard vent port between them to eliminate the danger



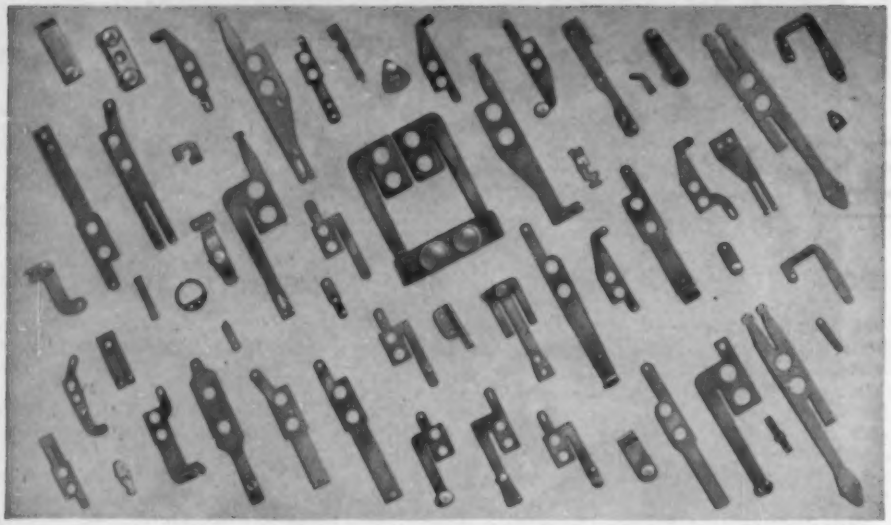
TRANSDUCER

A single-pole, variable-reluctance, angular-position transducer for FM/FM telemetering has been developed and marketed by Ultradyne, Inc. The device gives precise measurement of angular rotation by means of a new principle now awaiting patenting. Rotation of a magnetic rotor varies the amount of ferromagnetic material in a fixed air gap and, due to the shape of the rotor, a change in the magnetic reluctance varies the frequency of an oscillator in a linear manner.

The transducer has application wherever exact measurement of a small angular position change is required and high resistance to very severe shock and vibration is essential. Its uses include installation on rocket motor gimbals and actuators and control surfaces. The unit features an infinite resolution for smaller angular ranges without the use of gears or screw systems to obtain adequate output sensitivity.

There is no limitation of resolution such as is found in transducers utilizing potentiometers or similar sensing elements. The device requires no mechanical stops to prevent damage and good acceleration sensitivity is provided in all directions. The gage is supplied in two models, both identical except for one unit having a temperature range of 0°F-250°F.

Circle No. 207 on Subscriber Service Card.



CONTACT TRICON FOR CONTACTS

Tricon furnishes contact assemblies to the electromechanical industry and specializes in missile control applications. At Tricon you have a team of specialists in the manufacture of switch and relay spring-blade components, as well as precious metal contacts and assemblies.

The FINE PARTS WELDING AND BRAZING DEPARTMENT at Tricon is available to semiconductor manufacturers for the precision assembly of diodes and transistors. Make a good connection and contact Tricon for contacts.

Tricon MFG. CO.

PRECIOUS METALS FOR ELECTRONICS
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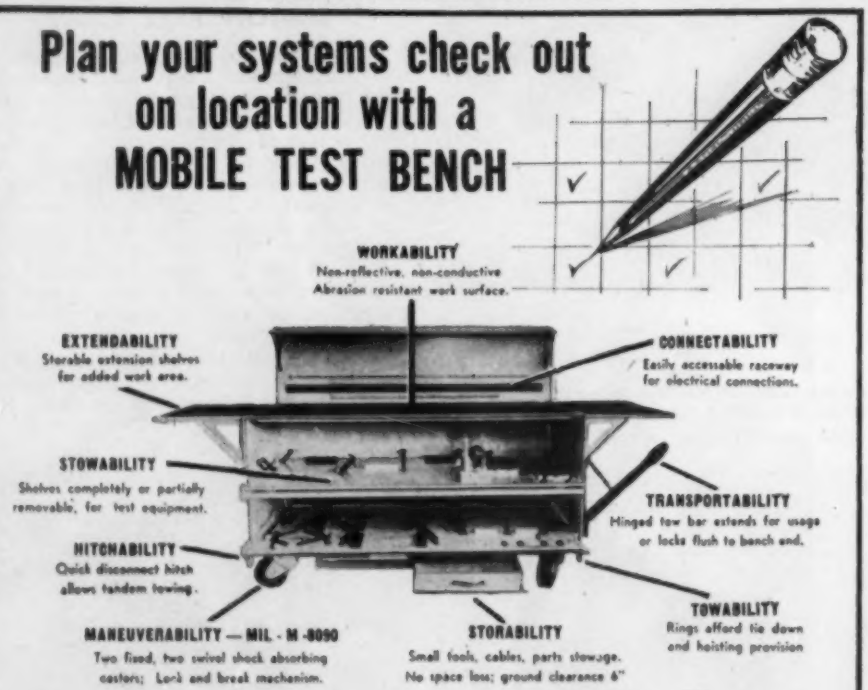
Circle No. 37 on Subscriber Service Card.

Plan your systems check out on location with a MOBILE TEST BENCH


WORKABILITY
Non-reflective, non-conductive Abrasion resistant work surface.
EXTENDABILITY
Storable extension shelves for added work area.
CONNECTABILITY
Easily accessable raceway for electrical connections.
STOWABILITY
Shelves completely or partially removable, for test equipment.
TRANSPORTABILITY
Hinged tow bar extends for usage or locks flush to bench end.
HITCHABILITY
Quick disconnect hitch allows tandem towing.
TOWABILITY
Rings afford tie down and hoisting provision
MANEUVERABILITY — MIL - M -8090
Two fixed, two swivel shock absorbing casters; Lock and break mechanism.
STORABILITY
Small tools, cables, parts stowage. No space loss; ground clearance 6"

Skydyne's aluminum faced sandwich construction benches provide versatile, compact, mobile units to facilitate on sight checkout of electronic systems or components of rockets and missiles. Specially engineered and designed to your requirements in size and layout or existing designs adapted to your needs.

Skydyne's experience and guarantee saves you time, money and responsibility.

Skydyne Inc PORT JERVIS, NEW YORK

Circle No. 38 on Subscriber Service Card.

of external leakage. The units are available for line sizes from ¼" to 2".

Circle No. 220 on Subscriber Service Card.

ACCELEROMETER

Development of a self-calibrating accelerometer, designed primarily for control and guidance in missiles, has been completed by Gulton Industries, Inc. Other applications intended for the device include fire control, servo guidance and pitch and yaw correction characteristics.

Designated the Glennite differential transformer accelerometer, model ADT-905, the unit is equipped with a self-

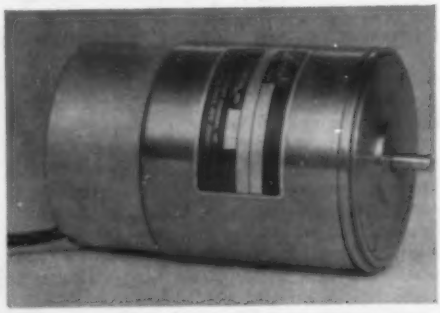
contained calibration system which can be used to check the operation of the accelerometer while in use, or to calibrate the unit statically or dynamically.

The device is inherently stable over the temperature range −65°F to 250°F. Operating at a low natural frequency of about 30 cps, the accelerometer maintains stable frequency-response characteristics over the temperature range as a result of magnetic damping.

Circle No. 200 on Subscriber Service Card.

HIGH-ACCURACY SYNCHRO

Kearfott Co. announces the development of a high-accuracy synchro component having a maximum error from electrical zero of only a half minute. A resolver-type unit, this synchro is capable



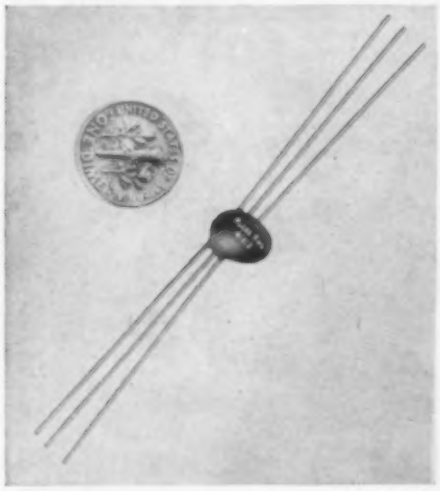
of functioning as a 4-wire control transmitter, control differential transmitter or control transformer which, when used in a 4-wire string to form a typical data transmission system, holds overall system

error to less than 1 minute from electrical zero. The unit may also be modified for operation at either 4000 or 10,000 cycles. A compensator winding is provided to maintain the revolver's 30-second accuracy despite variations in temperature and frequency.

Circle No. 205 on Subscriber Service Card.

PULSE TRANSFORMER

A tiny pulse transformer, no bigger than a pea, is now available from Pulse Engineering, Inc. Designated the ES3, this subminiature transformer is particularly useful in transistor-blocking oscillator circuits. Body dimensions for the epoxy-resin-encapsulated pulse transformer

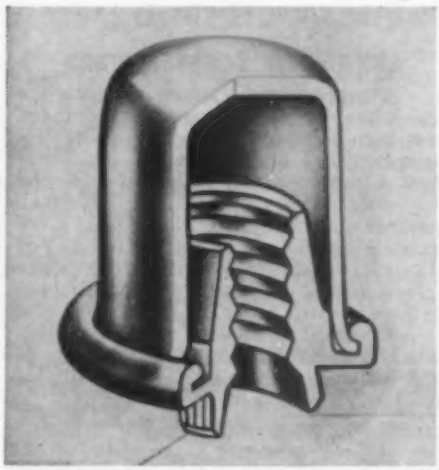


are ⅜" maximum. The ES3 is available in two- and three-winding styles with wire leads of No. 24 AWG tinned copper. Coil inductances to 3 millihenries are available. Power rating of the units is 1 watt average power and 50 watts peak pulse power.

Circle No. 209 on Subscriber Service Card.

MINIATURE CAPPED CLINCH NUTS

A miniature clinch-type self-locking nut designed with an integral metal cap has been developed by Elastic Stop Nut Corp. of America. The clinch-type fastener is mounted by expanding the short



knurled shank in the installation hole. It then becomes a "fixed" fastener, particularly suited for applications where restricted space will not permit normal wrenching procedures or where a "blind" nut is required to simplify maintenance.

The Clinch Nut, in 4-40, 6-32 and 8-32 threads, is designed with a shank length of .040" for use in material of .030" to .050". The 8-32 is also designed with shank of .060" for use in material .050" and greater.

Lightweight, miniaturized flush mounting and self-locking, the new nut meets torque requirements of AN-N-10 and/or MIL-N-25027 (ASG). Nut and cap are of heat- and corrosion-resistant steel.

Circle No. 202 on Subscriber Service Card.

GEAR BOX

A commercial application superspeed gear box, the gears of which reach rotative speeds in excess of 420 mph has been designed and manufactured by Western Gear Corp. for testing missile pumps. It is believed to be the first time that a high-speed unit operating at such speeds has been built for a permanent installation.

The precision gears of the two-speed box turn over at 67,000 rpm with a pitch line velocity of 37,303 fpm. Rated at 600 hp, the unit is about 2' long, 14" tall and 12" wide. It is trunnion-mounted and used as part of a dynamometer test facility.

Circle No. 211 on Subscriber Service Card.

SERVOFRAX DOME

Servofrax arsenic trisulphide glass, now available from Servo Corp., may be

molded, ground and polished to produce one-piece domes. Used in transmitting infrared radiation to infrared detection

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WELDING ENGINEER: Position involves fundamental studies of welding processes for high strength steels. Applicant should have appropriate engineering degree and some experience. Location, Western Pennsylvania research institution. Detail education and experience in first letter. Box 100-A, MISSILES & ROCKETS Magazine, 1001 Vermont Ave., N.W., Washington 5, D.C.

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CONSTANT!

- ► from −55° to +100°C
- ► thru 10 G's vibration
- ► over 1000 hours continuous operation

Avolt Standard*

TUBELESS CONSTANT VOLTAGE SOURCE

- **Replaces VR tubes and chemical cells**
- **For airborne, mobile and laboratory instrumentation**

Designed to provide dependable DC reference voltage wherever specifications demand long-term stability in the presence of environmental extremes. Uses no tubes or moving parts . . . conforms to shock, vibration and acceleration requirements of MIL-E-5272A. Negligible temperature coefficient, plus freedom from hysteresis and switching effects, make it readily applicable to the most critical measurement and control circuits. Weighs less than 3 ounces; requires less than 1.8 watts. Other features:

- **Small size:** 1 1/16" x 1 3/16" dia.
- **Life expectancy:** more than 10,000 hours
- **Base:** miniature 7-pin
- **Case:** hermetically sealed
- **Random drift:** less than 0.1% over 1000 hrs.

Models to meet wide range of application requirements: Inputs from 26.5V DC or 115V AC, 60 or 400 cycles. DC output 6.2V at 1 ma or 10 ma, 1V at 1 ma. Modified types can be developed to meet your particular needs. For complete specifications and performance data, write for Bulletin, (MR-200), Avien, Inc., 58-15 Northern Blvd., Woodside 77, N. Y.

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Precision Instruments and Control Systems

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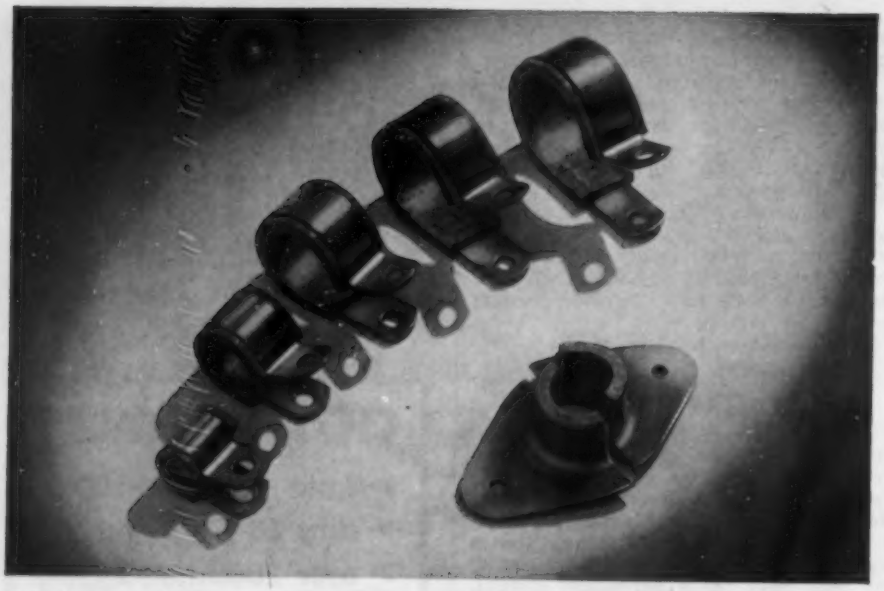

Anyone can make a metal clamp, but one lined like this takes a bit of doing

Take asbestos, reinforce with wire mesh, impregnate with DuPont Teflon and mold to shape . . . a new conception in high temperature clamps, one
–that will take temperatures from –300 to +500 F
–that will never harden nor melt
–that will stand corrosive fumes, oils, hydraulic fluids, solvents, fuels
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equipment, this shape is available in sizes from 4" to 12" in diameter and it may be ordered in any spherical section up to and including 180° hemispheres.

Servofrax domes withstand high acceleration and subzero temperatures without damage. The dome has a slight negative lens effect (as all concentric shells must), which sometimes can be used effectively as a Maksutov corrector for concentric optical systems.

Circle No. 214 on Subscriber Service Card.

GERMANIUM PHOTODIODE

External light-focusing devices or optics are unnecessary with a germanium photodiode developed by Nucleonic Products Co. The hermetically sealed, high-sensitivity device features a narrow integral lens which concentrates light on the sensitive portion of the junction area. It can be used in either the visible or infrared portions of the spectrum.

Sensitivity of the new device is approximately 30 mA/Lumen at an ambient temperature of 20°C. Operation is to a maximum ambient temperature of 50°C. Dark current is less than 3.5 microamperes. The sensitive surface is about 1 mm^2, and the overall dimensions are such that the device is adaptable to the most highly miniaturized equipment.

Circle No. 210 on Subscriber Service Card.

EXPANDED SCALE METERS

A new line of meters in which the scale has been electronically expanded has been developed by the Miller Instrument Co. By eliminating the lower unused portion of the scale and using the full scale to cover the range in which readings can be expected to fall, more accurate readings can be obtained. For example, on a voltmeter used to measure values around 28 volts, the scale could be expanded to cover 26 to 30 volts and values from 0 to 26 volts would be eliminated. Reading accuracy of 0.25% of true voltage is possible because of the absolutely linear expanded scale.

Circle No. 216 on Subscriber Service Card.

ULTRAPURE SOLVENT

A highly purified solvent guaranteed to contain no particles larger than 2 microns has been developed by the Penetone Co. The company states that labora-

tory grade Inhibisol is specially purified in a dust-free process, contains absolutely no residue and is the ultimate in a refined solvent.

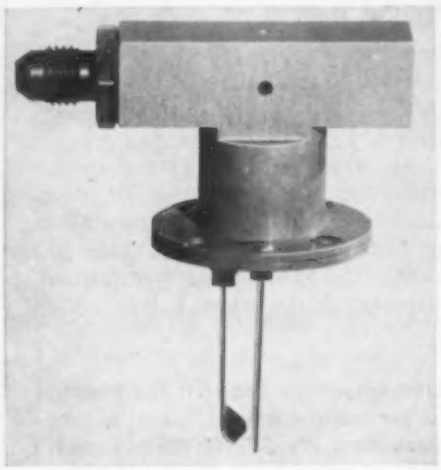
The product, now available in limited quantities, is designed primarily for manufacturers of precision instruments, electronic devices, bearings, watches, gyro contacts and controls and for cold-process cleaning where high purity is a "must."

Circle No. 212 on Subscriber Service Card.

TEMPERATURE PICKUPS

Designed for temperature control of liquids and gasses, the temperature pickups produced by Dynamic Controls Corp. can operate over a temperature range of −100°F to 500°F. The units are available in two types, which bleed a pneumatic control pressure on either increasing temperature or decreasing temperature.

Because the fluid to be sensed is in direct contact with the bimetal sensing element on all sides, very rapid response



times are provided. The thin bimetallic elements are placed parallel to the duct axis so that extremely low duct-pressure drops are produced. Units are available with elements shorter than 1" for ducts of small diameter. High sensitivity units are available to control temperatures within 1°F.

Circle No. 218 on Subscriber Service Card.

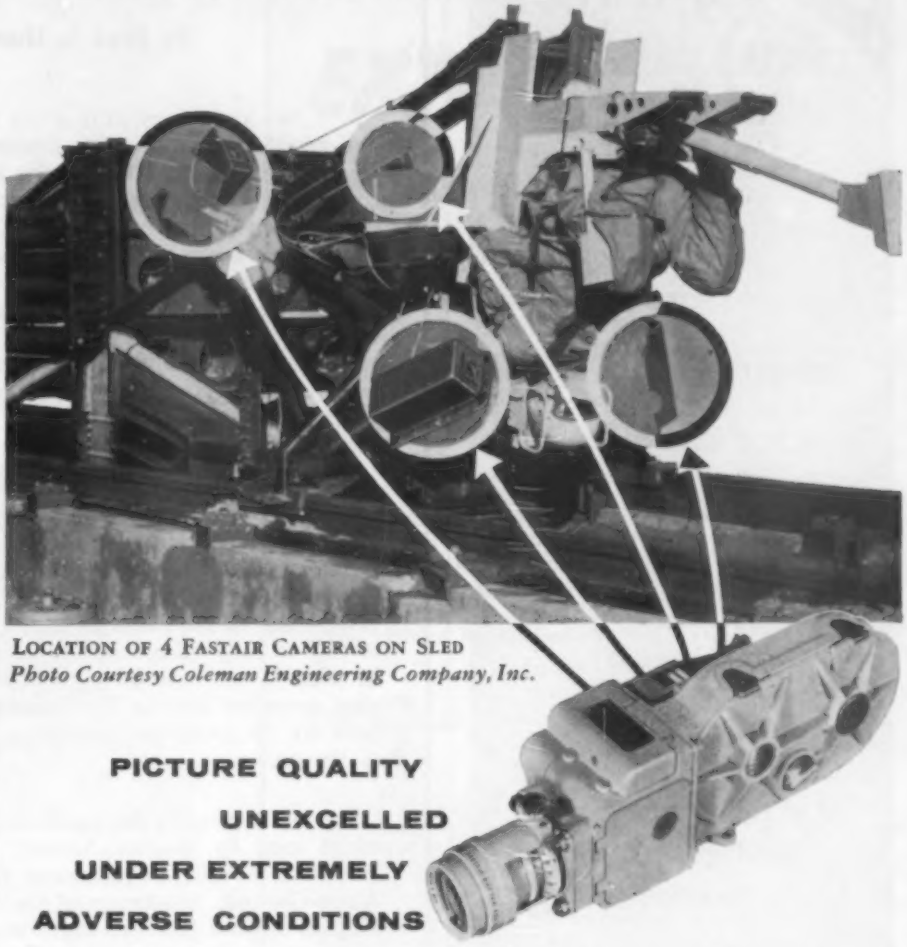
TRANSISTORIZED VIBRATOR

Vibration Research Laboratories, Inc., has developed a new type circuit component designated the Vibristor. The device, now in production, is a self-resonant, semiconductor interrupter designed to replace vibrators in existing power supplies and for use as a standard component in new equipment.

Replacement models use standard vibrator enclosures and bases for direct replacement of all commercial vibrators, both synchronous and interrupter types. Plugging the Vibristor into the vibrator power-supply socket completely transistorizes a power supply. No wiring or other circuit changes are necessary. Since operation of the Vibristor does not depend on magnetic saturation, no "current-spikes" occur and output ripple and noise are eliminated. Frequency remains within ±1% for input voltage changes of ±25%. Single units capable of switching up to 300 va at any frequency below 100 kc are available.

Circle No. 208 on Subscriber Service Card.

4 FASTAIR CAMERAS RECORD ROCKET SLED TEST...



LOCATION OF 4 FASTAIR CAMERAS ON SLED
Photo Courtesy Coleman Engineering Company, Inc.

PICTURE QUALITY UNEXCELLED UNDER EXTREMELY ADVERSE CONDITIONS

Despite the high acceleration, vibration and extreme G load of rocket sled test FASTAIR High-speed Missile Cameras recorded pictures of highest quality. Small, sturdy and compact, the FASTAIR, the first camera developed specifically for missile and rocket studies, is *unexcelled*. The FASTAIR can also be used in other fields requiring the recording of action for analyses. Speed ranges from 12 to 600 pictures per second.

Robert W. Drury reports the FASTAX *camera is a credit to the photo equipment industry . . . never had a failure of any part of the camera or the very well thought out Camera Control unit. The new* FASTAIR *camera has proven to be an outstanding missile-borne camera, well designed for the job.*

Photo Unit Supervisor, Lockheed Missile Systems Divisions, Palo Alto, California

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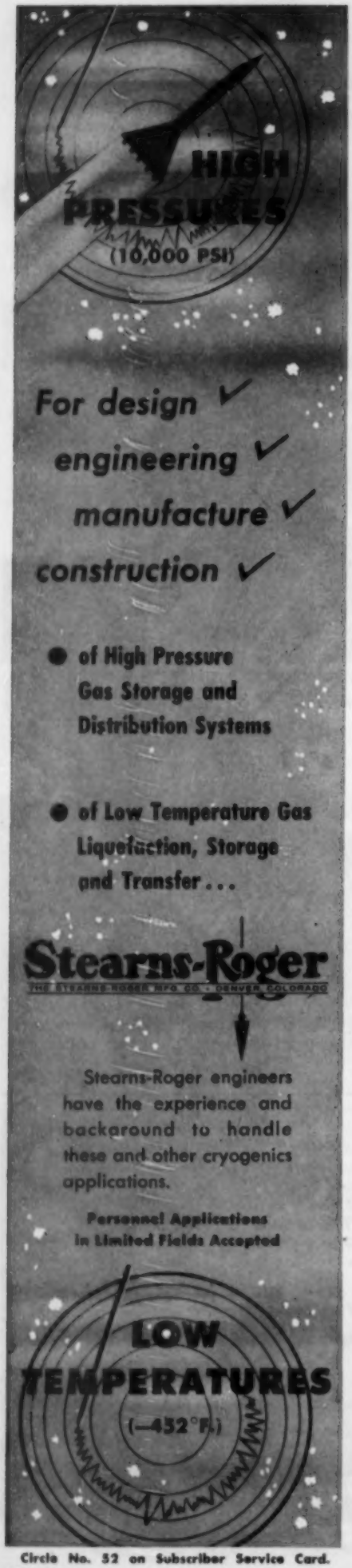

Circle No. 52 on Subscriber Service Card.

West Coast Industry

by Fred S. Hunter

We know very little about Convair's *Wizard Two,* the Air Force anti-missile missile, but it's interesting to note that this new defensive weapon will be a product of the San Diego division, where the military specialty is turning out airplanes with wings, rather than the Astronautics division, where they make missiles embracing the ballistics principle. The *Wizard* has wings, so it really falls in the classification of unmanned aircraft. It's also an interceptor, and they are old hands at this business in the San Diego division through experience with the systems used in the delta wing F-102 and F-106 jets. The *Wizard* mission is to intercept intercontinental—or intermediate-range—ballistic missiles on the inbound track, remaining within the atmosphere, but exploding at very high altitudes, somewhere in the area of 300,000 to 500,000 feet. The operational technique would be to fire several of them at the same time.

•

Dr. Ralph Bowersox, instrument development chief at the Jet Propulsion Laboratory, thinks it may be possible to develop a homing system so that a rocket to the moon can be guided to its lunar target by moonlight. It might be used with a small rocket fired as the space vehicle neared the moon to nudge it toward its target, and thus not have to rely so fully on precise orbital calculations. Such a rocket might also be used in the nose of an instrument package and fired as a brake to slow down for landing. The small rocket would be triggered by a certain intensity of moonlight activating the rocket brake when it was close to the moon.

•

HIP (Hughes Impact Point) is no longer the name of the ground target used by Hughes Aircraft Co. for air-to-ground firings at the Holloman Missile Development Center. Now it's STAG (Salt Target, Air-to-Ground). Expansion of the Holloman range made it necessary for Hughes to close HIP and move to a more remote site up range, so a new name was devised to avoid confusion between an old HIP and a new one.

•

Reports indicate that Raytheon's *Sparrow* III is about ready for fleet operations, and squadrons operating out of Alameda may be the first ones to undergo training. The missile continues to undergo testing at Point Mugu. Raytheon has had both a Douglas F4D and a McDonnell F3H on bailment from the Navy for its flight-testing on the newest model in the Navy's air-to-air *Sparrow* family. There are two variations of the *Sparrow* III, one the AAM-N-4 and the other the AAM-N-6. At least one is reported to be a heat-seeker.

•

Jigs for the *Thor* IRBM at Douglas are as big and massive as those for the DC-8 jet airliner . . . Elmer P. Wheaton, chief missiles engineer at Douglas, has the same status as a division chief engineer and reports directly to Arthur E. Raymond, vice president-engineering, but missile production at Douglas comes within the province of the Santa Monica division, and is under the supervision of the Santa Monica plant superintendent . . . North American Aviation obtained a patent on a method of electroplating metals on beryllium and rewarded the inventor, Joseph J. Utz of its missile development division, with a $500 award.

•

Lockheed is now wringing out a bigger Marquardt ramjet engine on flights over the desert range at Holloman . . . Electronics Investment Corp., an investment fund, recently picked up 18,182 shares of Cohu Electronics.

FOURTEEN BRISTOL HIGH SPEED RELAYS IN THIS CONVERTER!

Twelve-and-a-half microvolt resolution at 20 readings per second! That's the outstanding feature of the analogue-to-digital converter, developed by Non-Linear Systems, Inc., Del Mar, California, to "digitalize" the output of low voltage transducers in either ground or airborne service.

It's significant that Non-Linear Systems engineers selected fourteen miniature Bristol Syncroverter* high speed relays (inset, top) for use in the converter scanning circuits. For the Syncroverter was originally designed for use in our own Bristol instruments in extremely critical, low-level, dry-circuit applications. Its rugged non-resonant construction has earned it an enviable reputation for reliability, long life, and immunity to shock and vibration.

Write for complete data. Characteristics below are typical. The Bristol Company, 173 Bristol Road, Waterbury 20, Connecticut. 8.3

T.M. Reg. U.S. Pat. Off.

TYPICAL CHARACTERISTICS

Bristol's Syncroverter High-Speed Relay SPDT or DPDT (covered by patents)

Temperature range:	−55°C to 100°C
Operating shock:	30G; 11 milliseconds duration
Vibration:	10-55 cps (see below, mounting); 10G
Contact ratings:	Up to 35V, 45 microamperes
Stray contact capacitance:	Less than 15 mmf.
Pull-in time (including bounce):	As low as 200 microseconds
Drop-out time:	300 microseconds
Life:	Over a billion operations under dry-circuit conditions
Mounting:	Octal tube socket; others available, including types for vibration to 2000 cps

BRISTOL FINE PRECISION INSTRUMENTS FOR OVER 68 YEARS

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REPUBLIC VALVES FOR EVERY INDUSTRY

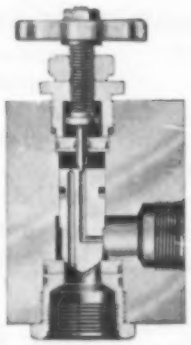
EXTRA HIGH PRESSURE FINE METERING

HIGH PRESSURE NEEDLE VALVE

10,000 psi hydraulic service. Forged stainless steel one-piece body. Panel mounting. Good flow characteristics, fine metering, easy to turn. Water, gas, oil and vacuum service, ⅛" to ½" pipe or straight thread tube connections.

MICROMETER ADJUSTMENT NEEDLE VALVE

Best for extra fine metering. Micrometer adjustment, precision taper stem. 5000 psi service −65° to 350°F., oil, water, etc. Brass, aluminum alloy, steel, or stainless steel body. ⅛" and ¼" sizes. Premolded or O-ring packing. Panel mounting.



5000 psi THROTTLE-FLO VALVE

Accurate throttling up to 5000 psi. Finger tip control. Pilot operation of large dynamically balanced piston. Full flow, yet accurate to 1/100 gpm through entire range. Positive seal. Low pressure drop. Aluminum alloy, ½", ¾", 1" internal straight thread connections. Hydraulic seals — others available.

HYDRAULIC BLEEDERS

Primarily used for bleeding air from hydraulic systems, for working pressures to 3000 psi at temperatures from −65° to 180°F.

Fluid control valves of many types have been developed and are manufactured by REPUBLIC. A wide line of quality standard valves includes needle, globe, check, plug, selector and relief valves, as well as other units for industrial, chemical, aircraft, missile and ground handling equipment.

Specialists in valving and manifold design to meet your specific application. Write for catalog.

Distributors in principal cities coast to coast

CHECK RELIEF SELECTOR GLOBE NEEDLE PLUG

RM REPUBLIC MANUFACTURING CO.

15655 BROOKPARK ROAD • CLEVELAND 11, OHIO

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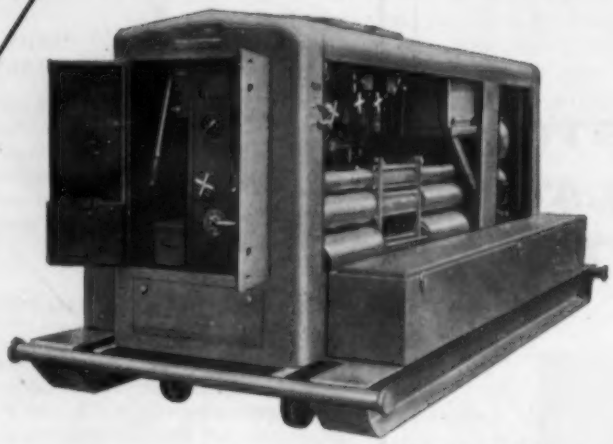
Oil free high pressure gas

FOR MISSILE PRESSURIZATION SYSTEMS



ASSEM. NO. 9200.
TACTICAL DIESEL ENGINE
DRIVEN 3-STAGE 6000 PSI
COMPRESSOR FOR ATLAS MISSILE

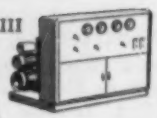
Haskel

MULTI-STAGE BOOSTER COMPRESSORS compress helium or nitrogen from a variable inlet pressure source such as commercial gas bottles to a higher outlet pressure.

COMPRESSION WITHOUT LUBRICATION prevents oil contamination and insures highest purity of outlet gas.

- OUTLET PRESSURES TO 10,000 PSI
- INLET PRESSURES FROM 50 PSI MIN TO 2,300 PSI MAX
- CAPACITIES FROM 1 SCFM TO 80 SCFM STANDARD
  (LARGER CAPACITIES ON REQUEST)

MODEL LS-III 40 TO 80 SCFM



FOR TEST SITES — STATIONARY

MODEL SM-III 5 TO 30 SCFM

FOR TEST SITES — SKID MOUNTED
AVAILABLE WITH ELECTRIC MOTOR OR GASOLINE ENGINE

MODEL LM-III 40 TO 80 SCFM

FOR TEST SITES — PORTABLE
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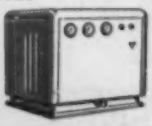

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people

Hunter C. Harrison has been appointed Washington, D.C., representative for Reaction Motors, Inc.

Emil L. deGraeve has joined the corporate staff of Litton Industries to undertake new development planning activities. He was previously with Stanford Research Institute.

R. L. Puette and **B. H. Carlisle** have been appointed general divisional managers by the Clark Controller Co.

John H. Hunt has been named director of manufacturing and **C. J. Jordan** production planning manager for Stavid Engineering, Inc.

Alfred A. Crivello has been named project engineer for microwave components operations at the Avion Division of ACF Industries.

R. T. Silberman has been named president of the Kin Tel division of Cohu Electronics, Inc.

HARRISON

deGRAEVE

Dr. Ernst Steinhoff has been appointed associate technical director at Aerophysics Development Corp. **Helmut Kuerschner** has been named chief of the computer operations projects office and **Werner K. Gengelbach** named assistant manager of Air Force missile projects at the same firm.

K. R. Herman and **C. C. Holschuh** have been elected executive vice presidents of Sperry Rand Corporation. Herman is responsible for operation of the Remington Rand group and Holschuh is responsible for operation of the group of companies that comprised the Sperry Corp. prior to its consolidation with Remington Rand.

Simultaneously, **J. F. Forster** succeeds Herman as president of Vickers Inc., a subsidiary of Sperry Rand, and **Dr. C. A. Frische** replaces Holschuh as president of Sperry Gyroscope Co. division. Other changes at Sperry Rand include the election of **James F. Toole** to the position of treasurer and **Charles Ondrick** to that of controller.

Edward R. Neumann has been appointed manager of the missile products division at Fruehauf Trailer Co.

Gordon H. Lafferty has been appointed chief test engineer at American Machine and Foundry Co.'s ballistic test station near Colorado Springs, Colo.

Fred S. Miller has been named manager of Aerojet-General's solid-propellant production at the Sacramento plant and **J. B. Cowen** has been named manager of manufacturing at the same facility.

GENGELBACH

Eugene B. Juratsch has been appointed contract administrator and **Ferdinand P. Diemer** named director of engineering at Cal-Tronics Corp.

Beverly Paxson has been placed in charge of computer applications for Donner Scientific Co. She was formerly with Beckman Instruments.

Dr. Ernst Weber has been elected president of Polytechnic Institute of Brooklyn, succeeding **Dr. Harry S. Rogers,** who died on June 6.

Chester A. Briggs will head Chance Vought's R&D section, established to plan, coordinate and direct engineering technical research and development programs. Also at Chance Vought, **Adrian H. Perry** will direct the firm's foreign representation.

R. J. Wright has been named manager of the Washington, D.C., office of the Garrett Corp., replacing **Myron A. Tracy,** who becomes manager of military contracts and support programs for the firm's military relations department.

Mrs. Laurence Delisle Pellier has been appointed applications chemist by the NORELCO Instruments division of Philips Electronics, Inc.

J. W. Woodruff has been appointed to the newly created post of manager, customer relations for Borg-Warner Corp.

Murray C. Walker, Jr., has been appointed New England regional manager of the military operations department of Allen B. Du Mont Laboratories, Inc.

Dr. B. D. Thomas has been named to the presidency of Battelle Memorial Institute, succeeding **Dr. Clyde Williams,** who is retiring.

Herbert H. Schenck has joined Page, Communications Engineers, Inc. as director of engineering.

Albert J. Harcher has been appointed to the new post of production manager at Clevite Transistor Products.

Robert T. Samuel has been appointed director of market planning on the corporate staff of IBM.

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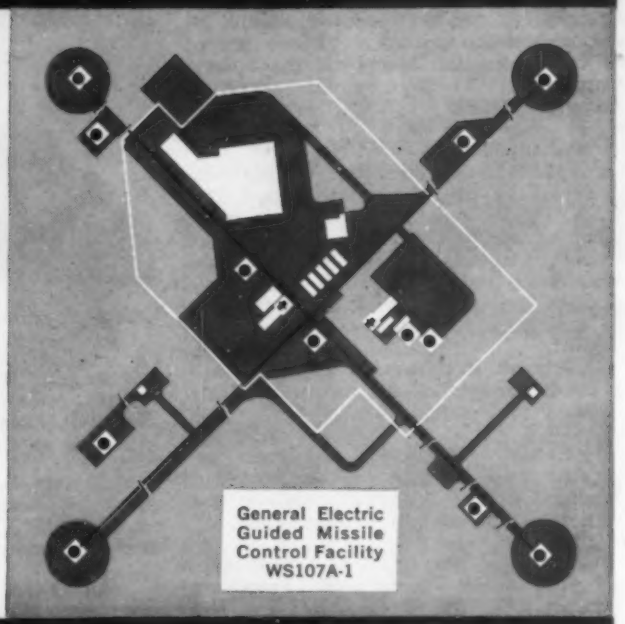

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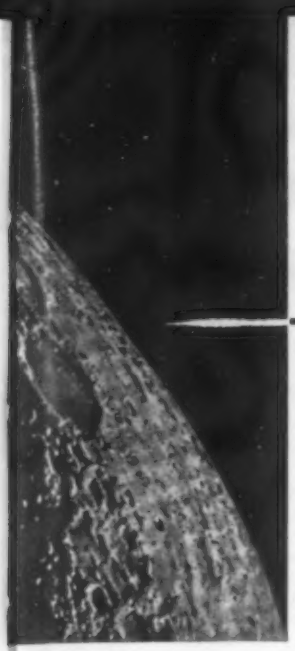

missile miscellany

Anybody still have doubts about the coming size of the missile market? If so, this page offers a few quick statistics to dispel them. Let's take Bomarc: A Bomarc launching site (birds not included) now costs $10 million. Only four have been ordered, but enough are now programmed to run the bill over $2 billion, still not including missiles. Proposed plans contemplate some 212 launching sites for North America with variously 115, 80 and 45 launchers per site. If these plans stick, just to fill up the programmed launchers with Bomarcs will take another $1 billion, and this doesn't include those in storage at each site. In a word, Bomarc program alone could easily run $5 billion at a minimum, and perhaps to as high as $10 billion before the first phase is fully completed. Total number of Bomarcs finally ordered may top 100,000. And Bomarc is but one of many missiles becoming operational!

With all the talk about U.S. superhigh radar and photoreconnaissance planes mapping the Soviet Union, and about SAC (and other) planes piercing the Iron Curtain to check Red defenses and their own ECM gear, its interesting to learn that AF first thought to do it with balloons—a program code-named Ferret—but dropped the idea in the face of State Department objections and the advent of better planes. This page also hears reports of Russia doing the same thing in Alaska, West Europe and Northern Canada.

And a Tass report that Russia is working on a plane "not subject to the laws of gravity" for trips "into the universe" coupled with a forecast by Prof. Kyril Stanyukovich (Soviet Academy of Sciences) that "the problem of gravity will be clarified to some extent in the coming year" raises some questions, particularly now that USAF has ordered captured German papers on the utilization of "free space energy" out of dead storage at Rand Corp. Sounds like the race for "antigravity" is picking up a bit. Meanwhile, Russians will try to get man into space and back before year end. First step will be to send him a couple of hundred miles up "capsuled" in the same kind of nose cone that carried last year's three-at-a-time dog experiments.

From China Lake, word that a monorail rocket sled hit 2575 mph in 1.9 seconds, a new record. Elsewhere, four outfits—Aerojet, Bell, Rocketdyne and NACA—have fired fluorine rocket motors—all under 5000 pounds thrust. Reports, too, that one large U.S. lithium firm has a way to make anhydrous lithium perchlorate at a cost near to that of making ammonium perchlorate. On the West Coast, this page sees that Giannini Research Laboratory has measured a specific impulse of 600 in a simple ion rocket using helium working fluid, with promise of a lot more from hydrogen. This is under an AFOSR contract.

Where East meets Middle East. The Japan Space Travel Society has made a gift of 3,600,000 square feet of land to Egyptian President Nasser—on Mars . . . Shell Oil Co. now has a grease with an operating temperature range from −45°F to 600°F . . . Fear's rising in Washington that Russia may be trying a global flanking move in Antarctica—permanence of Red IGY facilities there prompts some observers to conclude that Russia may be about to build launching sites for super-ICBMs and boost-glide skip bombers.

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CORE TUBES. Rectangular or round high-temperature core tubes or coil forms without flanges. Class H includes tubes of laminated silicone glass cloth designed to meet military specifications for electrical power and electronic equipment. Class B tubes of laminated polyester glass cloth or laminated epoxy glass cloth also available. Silicone Insulation, Inc.

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TRANSISTOR CIRCUIT POWER. A system for powering transistor circuits from electromagnetic energy radiated from distant sources, thereby eliminating the need for a local power source, is described in a report of Army research available through Office of Technical Services, Department of Commerce.

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TRANSISTORS. Information on how NOT to use a transistor, published in a booklet showing pointers in cartoon form. General Transistor Corp.

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MISSILE SUPPORT. Capabilities of Lycoming division of Avco Mfg. Corp. in missile-support field are covered in 16-page booklet. Lycoming Div., Avco Mfg. Corp.

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KEL-F PLASTIC. Corrosion resistant Kel-F plastic laminate which can be applied to any surface having almost any contour is described in bulletin by U.S. Gasket Co. Bulletin covers properties of plastic lining material, including extreme resistance to chemical action of acids, zero moisture absorption, heat resistance to 300°F, low-temperature flexibility, high-impact resistance, antihesive surface, and noncontaminating, nontoxic and nonflammable surface. United States Gasket Co. division of Garlock Packing Co.

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RADOMES. Developments in radome design and materials described in two reports of Air Force research. One covers streamlined lens-radome for airborne operations and the other covers advances in radomes for ground shelter of radar equipment. Available from OTS, Department of Commerce.

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CATALYTIC COATING. Illustrated color brochure on catalytic protective coatings describes characteristics of coatings as tremendous adhesion, durability and wear resistance, air-drying speed of 5 to 10 minutes, complete adaptability to any application technique and unusual heat and corrosion resistance. Industrial Finishes Co., Inc.

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MOLDING COMPOUNDS. A paperbound 40-page catalog describing the Atlas thermaflow reinforced polyester molding compounds, materials offering high-impact strength and unusual electrical and chemical resistant qualities. Catalog suggests that the materials replace metals and other plastics in many applications. Atlas Powder Co.

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TEFLON MATERIALS. Bulletin gives mechanical, electrical and chemical properties of C-D-F glass-supported Teflon in sheets, tapes, laminates, metal-clads and fabricated parts. Process of integrating glass-fabric base with outer layers of Teflon is outlined, with reference to impregnation process. Also details widths, nominal thicknesses, and thickness tolerances for standard and special grades of glass-supported Teflon tapes and other forms of material. Continental-Diamond Fibre Corp.

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PRINTED CIRCUITRY. A 180-page book containing lists of alternatives and recommended practices for each step of design and production; buyer's guide to special components; list of special tools and skills necessary; and a review of machine capabilities. Instruments Publishing Co., Inc.

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VACUUM PUMPS. High-vacuum-diffusion and booster-diffusion pumps covered in 12-page bulletin including outline drawings, tables, and large-scale speed curves. Full physical and operating specifications for both mercury and oil pumps with speed ranges from 10 to 11,000 cfm are presented. Also explains how diffusion pumps work, itemizes design and construction features and resulting benefits to the user, as well as present formulae used in designing high vacuum systems. NRC Equipment Corp.

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MINIATURE CONNECTORS. A four-page, four-color illustrated technical brochure giving specifications, diagrams and general information on microminiature connectors. Products meet MIL-C-8384 and are ruggedized to withstand shock and vibration extremes. Described in booklet series MM22. DeJur-Amsco Corp.

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THYRATRON GRID CONTROL. Four-page, illustrated bulletin describing packaged thyratron grid control providing economical power regulation up to 10 kilowatts. Provides simple circuitry, and one unit will control 1 half-wave or 2 full-wave thyratrons. VacTrol Engineering, Inc.

Circle No. 154 on Subscriber Service Card.

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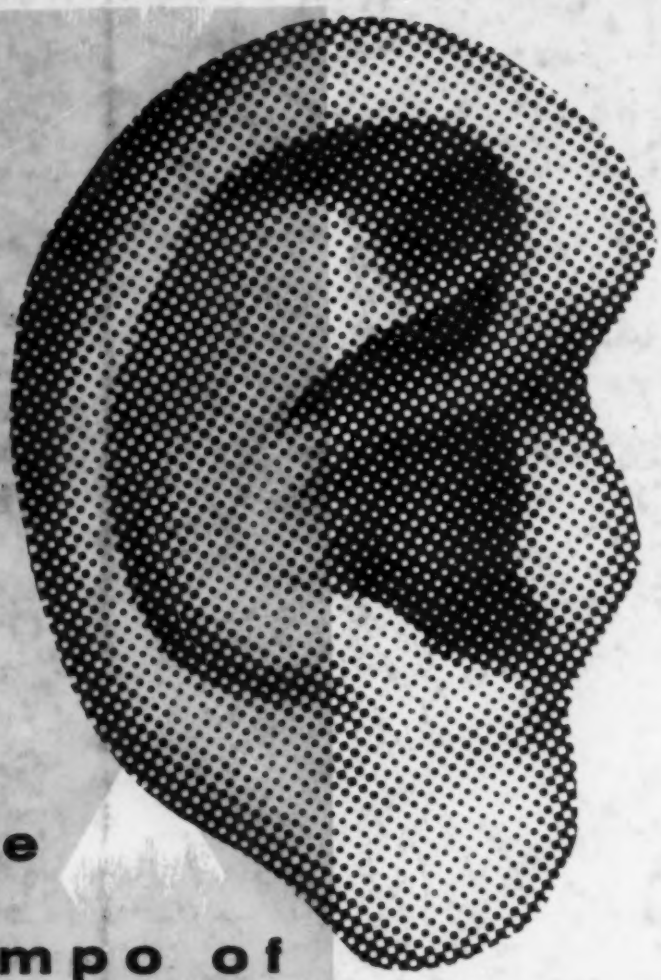

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